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EDN

Boards acquire and process video images in real time

Autorouters lay out multilayer pc boards

Intelligent modem ICs

Technical-article database index

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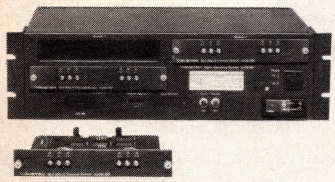

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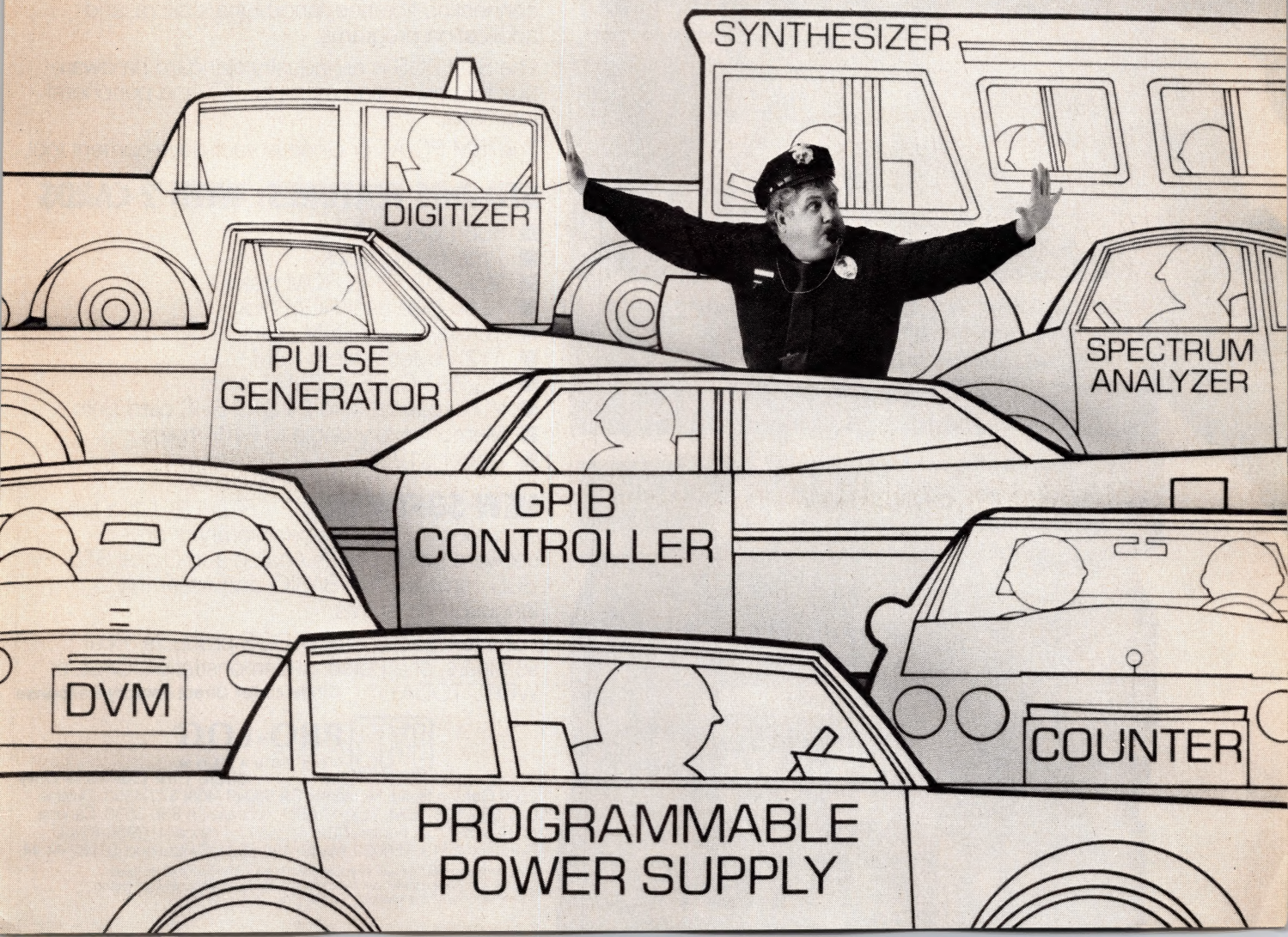

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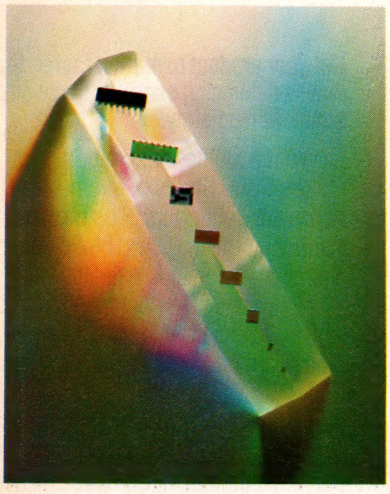
Volume 31, Number 16

EDN

August 7, 1986

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Surface-mount technology is allowing resistor packages to approach the dimensions of the resistors themselves. See pg 140. (Photo courtesy Allen-Bradley Co)*

DESIGN FEATURES

Special Report: Resistor chips, networks, and discrete resistors 140

Electronic packaging's evolution toward surface-mount components is forcing a transformation of the US resistor industry: New product types; new methods of assembly and manufacture; and the divestment, acquisition, and merging of companies are giving the industry a new look.—*Tarlton Fleming, Associate Editor*

Defensive programming simplifies program maintenance 157

By programming defensively, you can write software that adapts easily to changes in program requirements and hardware. Defensive-programming techniques also make your programs simple to read, to debug, and to modify.—*EDN Staff*

μP-based control scheme can enhance printer performance 165

Split-second timing performance is an absolute must in high-speed daisywheel printers. A master/slave μP control system can readily satisfy this requirement. Combining a burst- or interrupt-interface system with a time-sharing acknowledge strobe contributes to this efficient and economical way of operating printers.—*Don Dempsey, Xerox Corp*

1986 Technical-Article Database Index 169

EDN's semiannual database index lists major articles published from November 1985 through April 1986 in EDN, Electronic Design, Electronics, Electronic Products, and Computer Design.—*EDN Staff*

Continued on page 7

EDN (ISSN 0012-7515) is published 45 times a year, biweekly with one additional issue in January, February, March, August, and December, two additional issues in April, June, July, September, and November, and three additional issues in May and October by Cahners Publishing, A Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158. William M Platt, President; Terrence M McDermott, Executive Vice President; Jerry D Neth, Vice President of Publishing Operations; J J Walsh, Financial Vice President/Magazine Division; Thomas J Dellamaria, Vice President Production & Manufacturing; Terrence McDermott, Group Vice President. Circulation records maintained at Cahners Publishing Co, 270 St Paul St, Denver, CO 80206. Second class postage paid at Denver, CO 80202 and additional mailing offices. Postmaster: Send address changes to EDN, 270 St Paul St, Denver, CO 80206.

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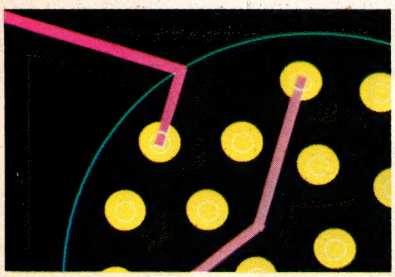
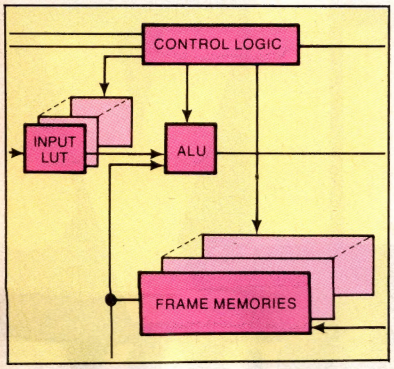


***Gridless autorouters** easily complete connections on dense pc boards, especially ones designed to hold surface-mount devices (pg 67).*



***Add-in image-processing boards** perform functions ranging from simple threshold adjustments to math-intensive filtering operations (pg 103).*

TECHNOLOGY UPDATE

Autorouters use sophisticated algorithms to lay out complex, multilayer pc boards 67

Autorouters employ rip-and-reroute, maze, gridless, look-ahead, hugging, bus, and strategy algorithms, and even combinations of these algorithms. The different algorithms can produce very different results, so the autorouter that will suit your purposes depends largely on the type of design you'll be laying out.—*Eva Freeman, Associate Editor*

Intelligent modem ICs integrate functions, simplify design of communications circuitry 85

Using the latest generation of modem ICs, digital designers can embed 1200- and 2400-baud communication facilities within their products. Except for the data-access arrangement—the rather complex circuitry that serves as the interface to the phone line—the designer needs few components other than the modem chips to implement the modem function.—*Maury Wright, Regional Editor*

Versatile add-in boards acquire and process video images and graphics in real time 103

Add-in boards that let computer systems acquire video images and process them in real time shouldn't be confused with boards that simply digitize an image and store it in memory for the computer. Image-processing boards include video-output and frame-storage sections as well as the video-input section that enables digitization. —*Jon Titus, Senior Editor*

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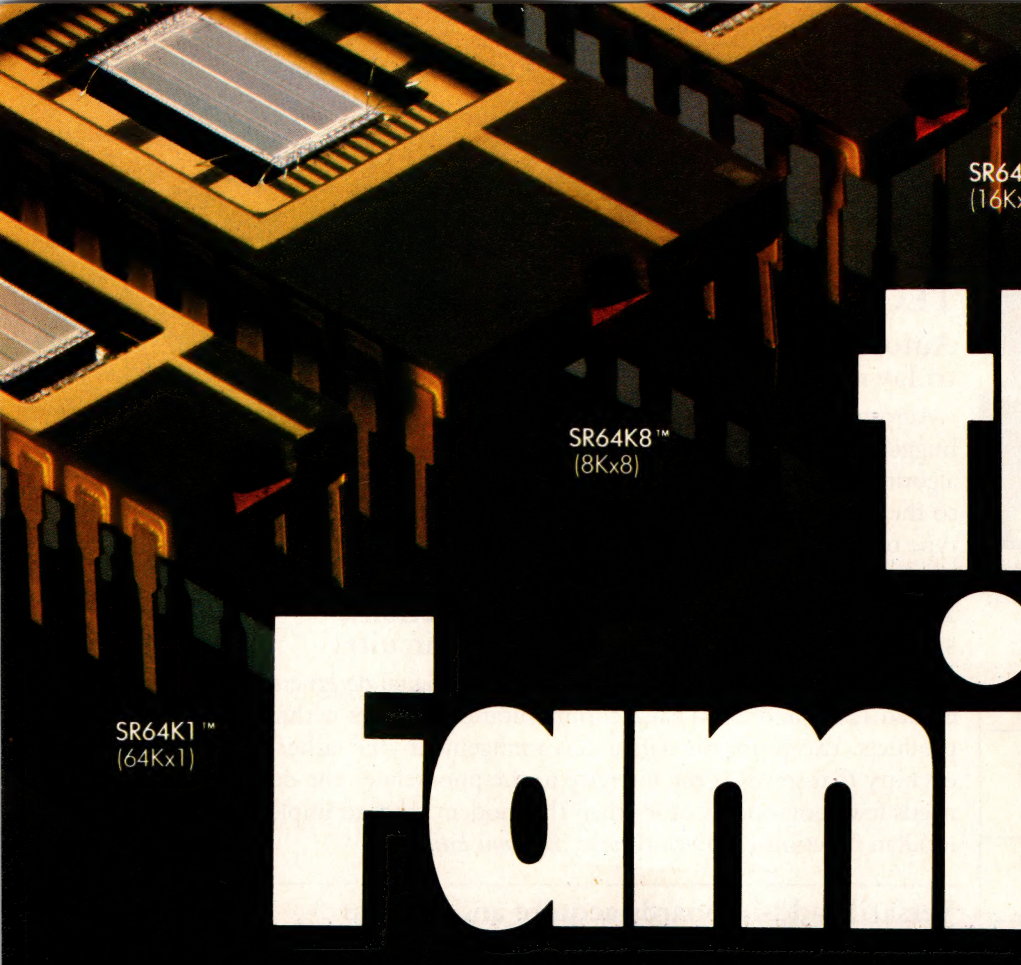

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EDITORIAL 51

Selecting the right products for your designs is one of the most important aspects of your job. Now, EDN gives you and your colleagues a chance to help each other in your quests. How? By enabling you to make known your selections of the best new products.

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Industry needs design-automation experts to unleash the power of supercomputers.—*George Stubbs, Staff Editor*

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Semiconductor industry to make gains through '87 . . . Feds to enrich telecomm market by $3.9B in '90.

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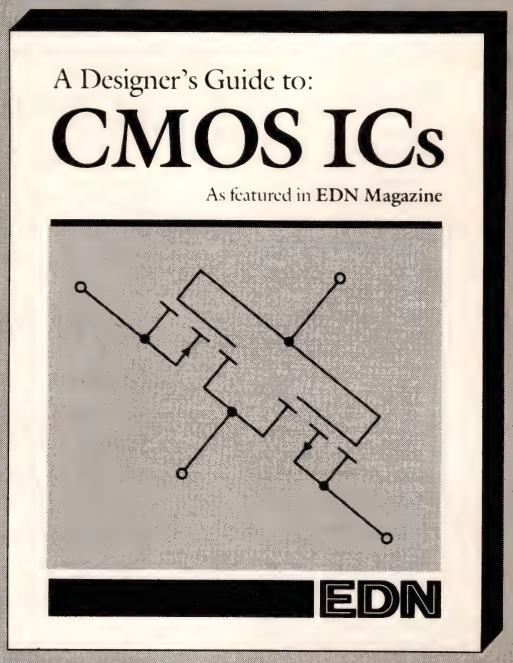

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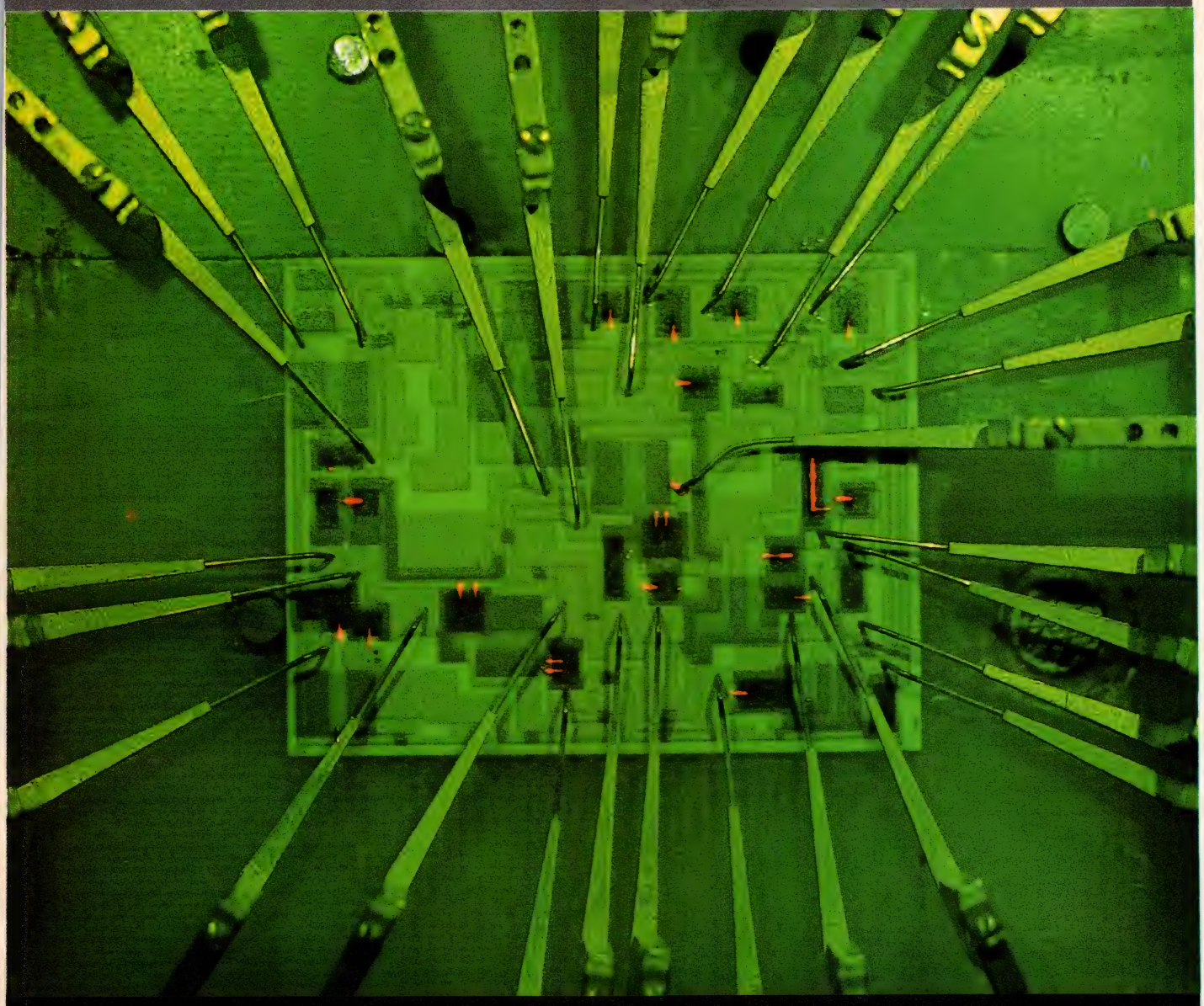

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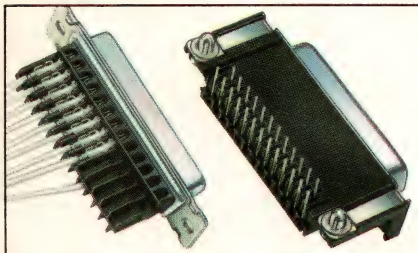

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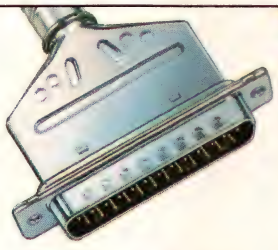

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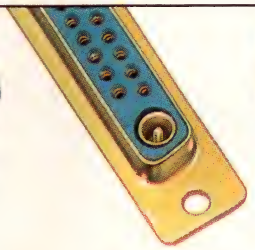

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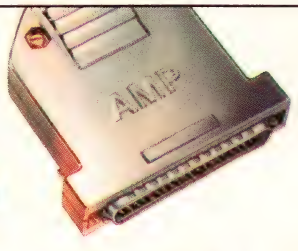

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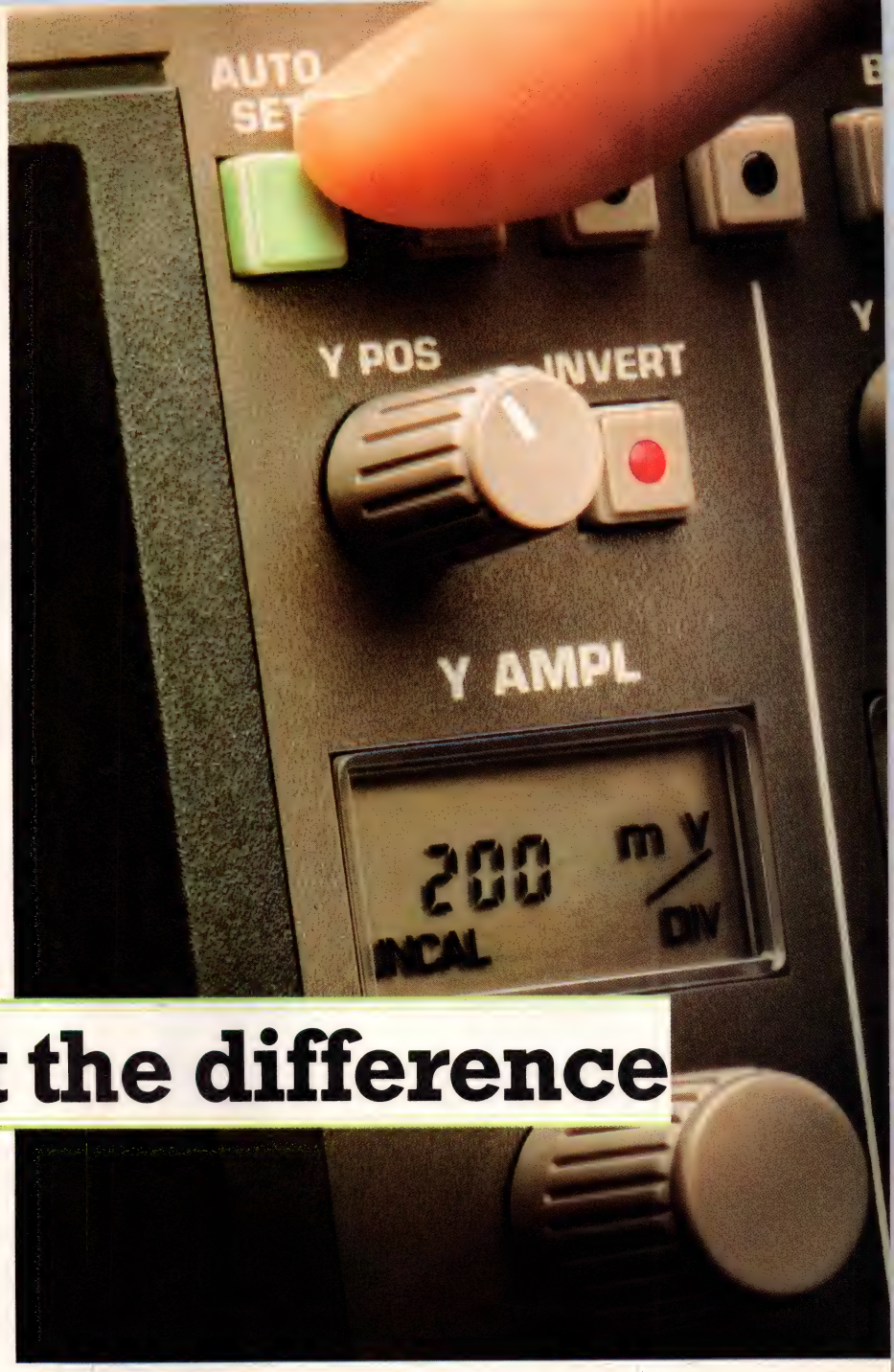

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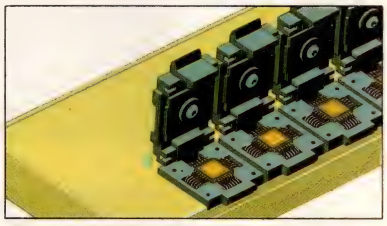

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EDITED BY GEORGE STUBBS

PC-BASED, 4-CHANNEL DIGITAL SCOPE HAS 128k-BYTE BUFFER

The R4x4 PC-based digital scope from Rapid Systems (Seattle, WA, (206) 547-8311) features individual 8-bit A/D converters for each of its channels, enabling you to acquire four signals simultaneously. The programmable sample rates (per channel) range from 0.1 Hz to 500 kHz in a 1/2/5 sequence. Each channel's data buffer is 32,767 bytes deep; you can partition the buffer into pre- and post-trigger segments under software control. The unit costs $1995.—Margery S Conner

CAE SOFTWARE SIMPLIFIES ANALOG DESIGN PROJECTS

Tools that assist analog designers are becoming as commonplace as CAE packages for digital designers. For example, Daisy Systems Corp (Mountain View, CA) and Valid Logic Systems Inc (San Jose, CA) are each porting their respective analog CAE packages to the IBM PC. Daisy's $33,000 Personal Analog workstation includes the company's DSpice circuit simulator, a 20M-byte hard disk, an 80287 coprocessor, and 3.25M bytes of RAM. Valid's Analog Designer AT, which requires a 32-bit coprocessor board, includes such virtual instruments as a mock function generator, a voltmeter, and an oscilloscope. The $31,950 Analog Designer AT includes hardware and software; software upgrades cost $10,500.

Analog Design Tools (Menlo Park, CA) is adding the Smoke Alarm reliability-analysis package to its Analog Workbench. The optional module evaluates the operating conditions (including derated conditions) of all circuit elements, and it issues a warning if any components are outside their safe operating areas. Smoke Alarm costs $10,000 for Sun-, Hewlett-Packard-, and Apollo-based versions; the IBM PC-based version costs $6000. Analog Design Tools has also announced an agreement with FutureNet (Canoga Park, CA); the Analog Workbench now interfaces to FutureNet's Dash schematic-editor and logic-verification package.

Analog-IC designers will benefit further from an agreement between International Microelectronic Products (San Jose, CA) and Silicon Compilers Inc (San Jose, CA). The companies will develop an analog-IC compiler that uses IMP's analog functional blocks.—Eva Freeman

CMOS VERSION OF 16-BIT 29117 μP CONSUMES LESS THAN 1W

Offering high speed and low power consumption in a 68-pin package, the 16-bit, CMOS Am29C117 from Advanced Micro Devices (Sunnyvale, CA, (408) 732-2400) provides both pin and function compatibility with the company's existing bipolar Am29117 μP. Not only does the CMOS version consume less than 1W, but it also offers a 15 to 30% performance improvement over the Am29C116 16-bit CMOS μP. Other features include a flow-through architecture with dedicated I/O ports, a barrel shifter, 32 working registers, a 3-input ALU, and a priority encoder. The Am29C117 costs $95 (100).—J D Mosley

RIMTECH FORMED TO COMMERCIALIZE NASA/JPL TECHNOLOGY

Rimtech (Los Angeles, CA, (213) 476-0618) is a newly formed, nonprofit organization representing companies in the private sector that, for a yearly membership fee of $25,000, will have access to technology developed by NASA's Jet Propulsion Laboratories (Pasadena, CA). The initial four companies participating—Alpha Micro Systems, AST Research, Cal-Comp, and Emulex—plan to develop products based on NASA/JPL's work in image processing, artificial intelligence, algorithmic data storage and retrieval, and data storage and compression.—Margery S Conner

NEWS BREAKS

DIFFERENTIAL COMPARATORS HANDLE HIGH-SPEED DATA TRANSFER

Texas Instruments (Dallas, TX, (214) 995-2481) has introduced two bipolar Schottky digital comparators that can serve as read-chain data comparators for high-speed disk memory. The TTL-compatible TL712 has complementary 3-state outputs with enable capability, a 25-nsec response time, and a 0 to 5V common-mode input-voltage range. The ECL-compatible TL721 offers a 10-nsec response time and a 0 to −5.2V common-mode input-voltage range. Both parts come in 8-pin packages and cost $0.72 (100).—J D Mosley

HIGH-SPEED COMPUTERS ACCELERATE CAE APPLICATIONS

By porting their CAE programs to high-speed, general-purpose computers, several software vendors are decreasing the run times of their packages. GenRad (Milpitas, CA), for example, is offering a port of its Hilo-3 logic and fault simulator to Ridge Computers' (Santa Clara, CA) 3200 computer system, a 4-MIPS computer that features a RISC architecture. Meanwhile, four CAE software vendors are exploiting the 12-CPU parallel-processing architecture of the Elxsi (San Jose, CA) 6400 computer. The new ports to the 6400 system are ECAD's (Santa Clara, CA) Dracula, Silvar-Lisco's (Santa Clara, CA) DVS, Meta-Software's (Campbell, CA) HSpice, and Tektronix's (Austin, TX) Merlyn-S. Dracula and DVS are IC-layout verifiers, HSpice is a circuit simulator, and Merlyn-S is a standard-cell layout package.

Cadnetix (Boulder, CO) is using parallel processing to accelerate the overall speed of its design-automation system. The company is including MIPS Computer Systems' (Sunnyvale, CA) parallel-processing computer in its CDX-760 global accelerator. The $29,900 CDX-760, which will be available in the fourth quarter of this year, compiles drawings and accelerates circuit simulation.

Mentor (Beaverton, OR) has been selling a parallel-processing computer for CAE, called the Compute Engine, but it's now introducing a package, the Development Station, that enables you to develop Fortran and Pascal programs in a parallel-processing format. In its basic package, the $29,900 system consists of one language compiler and an Apollo DN3000. Shipments will begin in October.—Eva Freeman

INEXPENSIVE PROGRAM BRINGS DESKTOP PUBLISHING TO IBM PC

For only $89.95 you can turn your IBM PC or compatible computer and a Hewlett-Packard LaserJet printer into a typeset-quality production center for engineering proposals, manuals, and documents. The PowerText Formatter from Beaman Porter Inc (Harrison, NY, (800) 431-0007) works in concert with any word processor or editor that can produce standard ASCII files. The user sets up format files that describe the desired appearance of the document. Then the PowerText Formatter uses these layout definitions to drive the printer.

You can specify such functions as automatic table generation, superscripts and subscripts, double-width printing, proportional spacing, italics, bold printing, automatic outline generation, and multiple-column formats. You can call the program from dBase II and III programs for reports, catalogs, and listings.—J D Mosley

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NEWS BREAKS: INTERNATIONAL

BY PETER HAROLD

CMOS FIFOs FEATURE PROGRAMMABLE FLAG AND PARITY LOGIC

The MV61902 and MV61903 Dipstick FIFOs from Plessey Semiconductors (Swindon, UK, TLX 449637) are CMOS 1k×9-bit FIFO memories capable of throughput rates as high as 10M bytes/sec. Both FIFOs incorporate a dual-port RAM architecture; input and output registers in the data path spec zero input hold time and a 20-nsec delay between the shift-out input and valid-data output for ease of interfacing. You can cascade the FIFOs in width and depth, and by utilizing the independent asynchronous 3-state output-enable input, you can operate two devices in parallel to form a 20M-byte/sec, 2k×9-bit FIFO system.

A user-programmable flag allows you to generate a flag output when a specified number of FIFO locations are occupied—a useful feature in delay-line and pipelined systems. The MV61903 features on-chip parity generation and checking circuitry, which protects all data transfers between parts of a system while it's operating at the full 10M-byte/sec shift rate. Samples of these FIFOs and samples of an industry-standard 1k×9-bit part, the bipolar MV61901, will be available during the fourth quarter. The MV61901 will cost $39, the MV61902 $55, and the MV61903 $60 (1000).

EUROPEAN COMPANIES JOIN FORCES TO BUILD ISDN CHIPS

Following the decision of Philips Elcoma Div (Eindhoven, The Netherlands, TLX 51573) to adopt the ISDN-oriented-modular (IOM) architecture and associated interface developed by Siemens (Munich, West Germany, TLX 5210025) for connection of subscriber-line equipment to the Integrated Services Digital Network system, the two companies have announced a joint venture to develop suitable interface ICs. First silicon of two ICs—an echo-cancellation IC for the U-reference point in the circuit and an IST bus-interface IC—are scheduled for evaluation during the last quarter of 1986. The IST bus-interface IC will allow you to implement an ISDN-compatible local-area network for as many as 31 voice and data terminals.

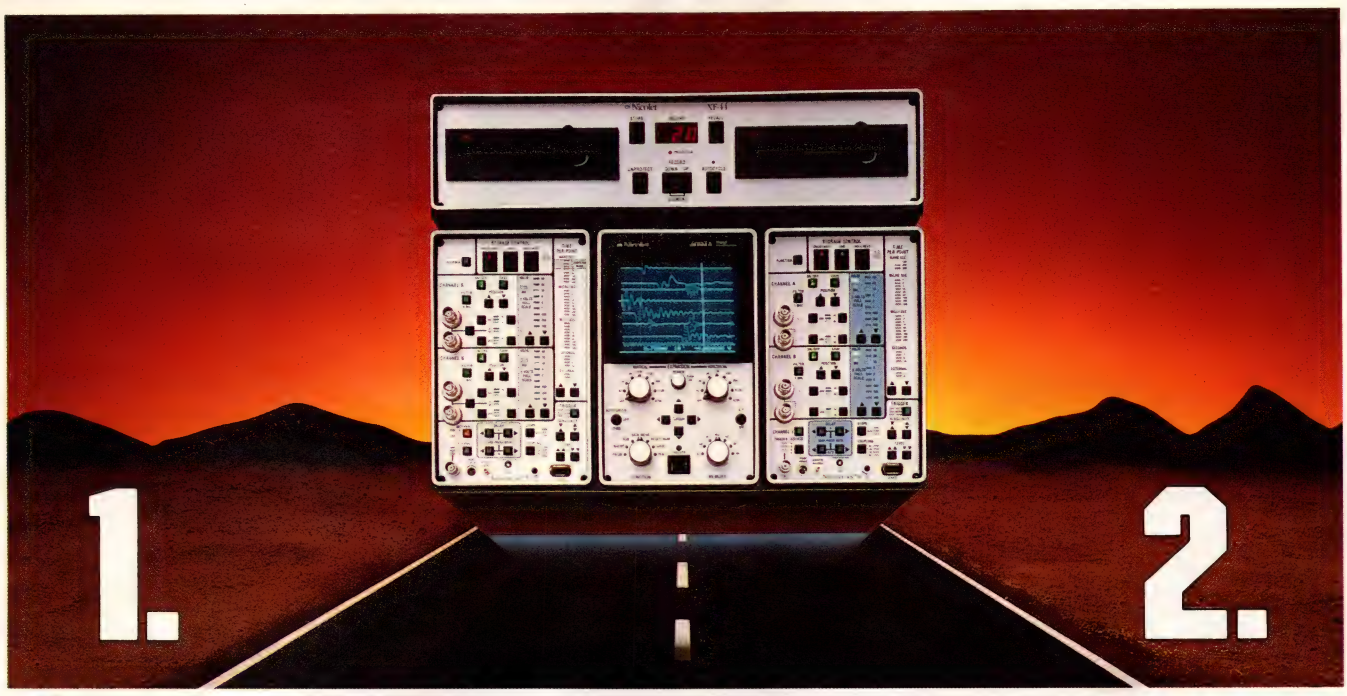
CHIP SET PROVIDES ANALOG FRONT-END TO DSP-BASED MODEMS

Three CMOS ICs, the TS68950 transmit interface, the TS68951 receive interface, and the TS68952 clock generator, form a chip set that provides you with a complete modem analog front-end (MAFE) for a DSP-based modem. Developed by Thomson Semiconductors (Velizy, France, TLX 240780) for use with its TS68930 and TS68931 DSP ICs, the chip set is intended for designs of full-duplex, echo-cancelling modems. It incorporates 12-bit, 50-μsec-conversion-time A/D and D/A converters and associated S/H circuitry, plus circuitry for the subtraction of local echo, for the adaptive cancellation of echo on the telephone line, and for automatic gain control. Two independent, digitally controlled PLLs allow you to generate Tx and Rx clock signals. Samples of the MAFE chip set should be available by the fourth quarter of 1986.

ATE WORKSTATION TESTS BARE OR LOADED PC BOARDS

Priced between £18,000 and £35,000, the Station-20 ATE workstation from AQL Automation (Bognor Regis, UK, TLX 946240) features as many as 2048 continuity test points, 1024 analog in-circuit test nodes, and 512 bidirectional, digital nodes. Variable-continuity test thresholds allow you to test bare or loaded pc boards, and the ATE workstation performs 6-wire in-circuit analog measurements and dual-threshold logic tests. The company's symbolic, English-based ATE software has full editing facilities for rapid program changes.

THE FIRST NAME IN DIGITAL SCOPES



TWO DIGITAL SCOPES IN ONE.

The Acquisition.

With sweep speeds from days to nanoseconds and resolution up to 15 bits, the 4094 digital 'scope can capture the most elusive signals. Every plug-in has 16K of memory, viewable trigger set-up and independent pre- or post-trigger delay on each channel. Signal averaging is standard and our latest 10 MHz/12-bit plug-in even offers real time manipulation of the incoming signals. With two plug-ins the 4094 can record four channels simultaneously. Or even monitor two slow signals and capture high speed glitches at the same time. All under computer control or via manual operation: whatever your application demands.

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Expand and examine any waveform feature in detail. Use the dual cursors and numerics to measure the time or voltage of any point. Compare live or stored waveforms with each other or with pre-recorded references. Store signals on disk manually or automatically. Use pushbutton programs to manipulate the data or send it to your computer via GPIB or RS232 interface. Complete your report with a hardcopy plot using the XY/YT recorder or digital plotter outputs.

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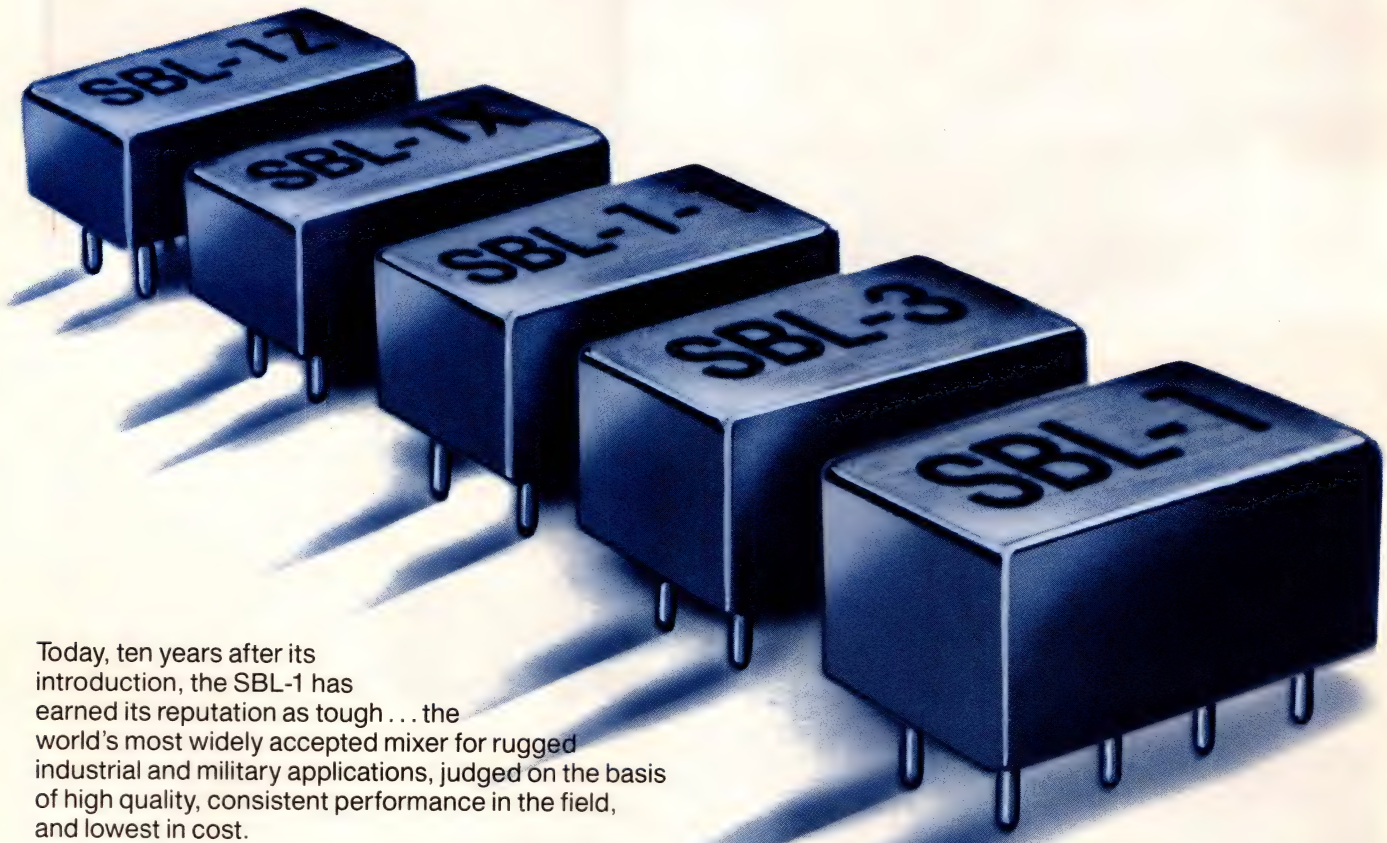
Nicolet

For More Information Circle 3

more tough mixers



Today, ten years after its introduction, the SBL-1 has earned its reputation as tough . . . the world's most widely accepted mixer for rugged industrial and military applications, judged on the basis of high quality, consistent performance in the field, and lowest in cost.

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Using the latest automated production and test equipment available, Mini-Circuits stress tests each individual component before assembly and then subjects each assembled SBL-1 to 17 grueling tests before acceptance, date coding and close checking for unit-to-unit repeatability.

The SBL-1 does have one drawback however. It only covers 1 to 500 MHz. That's why we've expanded the product family with additional models to cover 25 KHz to 1000 MHz. The new units are assembled with the same production and test expertise as the SBL-1; that's why we can offer 0.1% AQL on all SBL models . . . no rejects, not a single one, on every order shipped. So don't compromise your design or settle for a poor imitation. Specify Mini-Circuits SBL Mixers.

For full specifications call or write for latest RF/IF Signal Processing Handbook or refer to EEM, Gold Book, or Microwaves Directory.

SBL SPECIFICATIONS (typ.)

Model	Freq. (MHz)	Conv. Loss	Isolation, dB L-R	Isolation, dB L-I	Price (10-49)
SBL-1	1-500	5.5	45	40	**$4.50**
* SBL-1X	10-1000	6.0	40	40	**$5.95**
SBL-1Z	10-1000	6.5	35	25	**$6.95**
SBL-1-1	0.1-400	5.5	35	40	**$6.50**
SBL-3	0.25-200	5.5	45	40	**$7.50**

* If not DC coupled.

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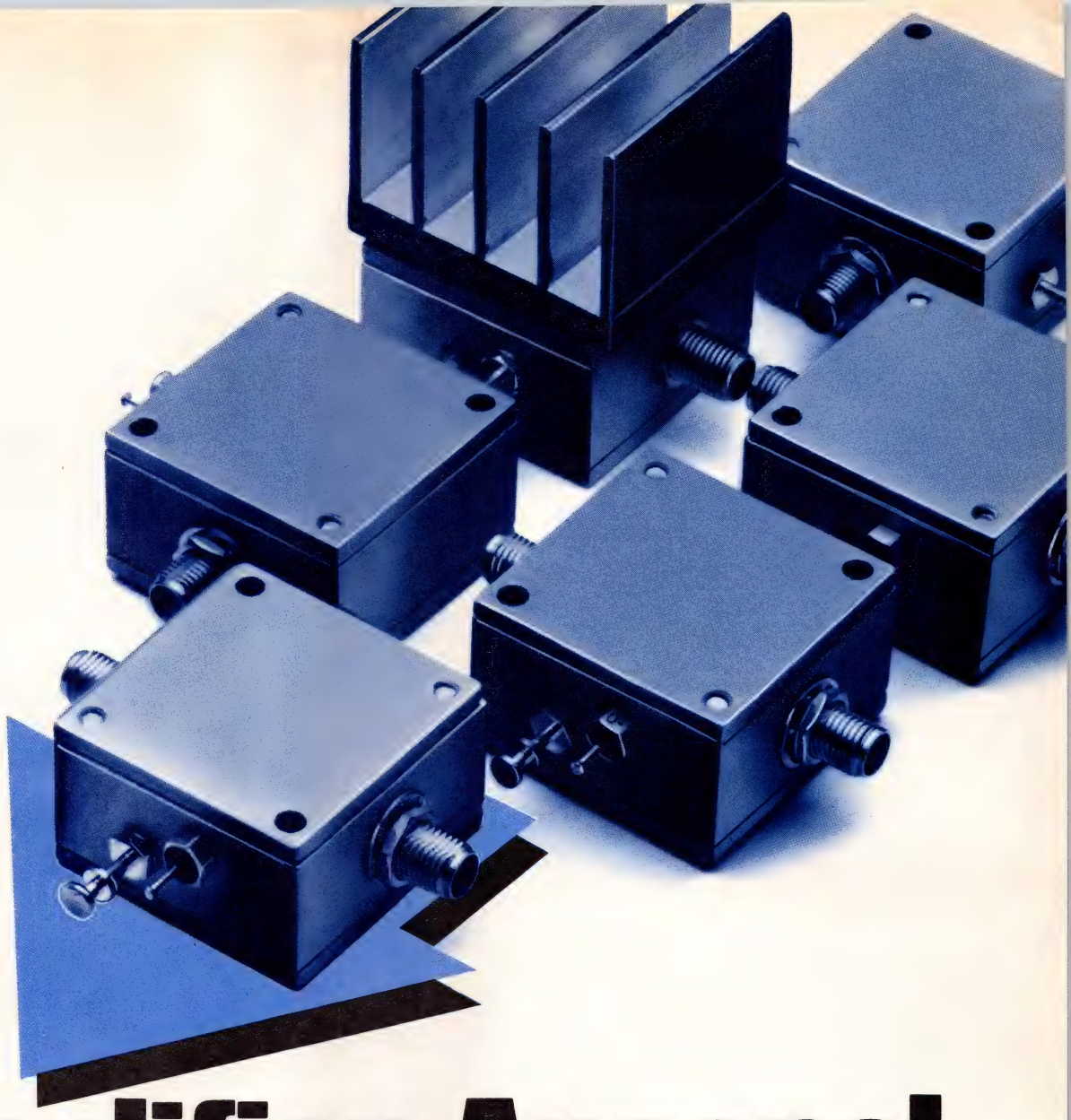

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50KHz to 2000MHz, 100mW output Gain Controlled From $69.95

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SPECIFICATIONS

Model No.	ZFL-500	ZFL-1000G	ZFL-2000	ZFL-1000H
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Gain (dB), Min.	20	17	20	28
Gain Flatness (dB) Max.	±1.0	±1.5	±1.5	±1.0
Max. Power (dBm) (1dB compression)	+10	+3	+17*	+20
NF (dB) typ.	5.3	12.0	7.0	5.0
3rd order Intercept pt (dBm)	+18	+13	+25	+33
Current at 15V dc	80mA	90mA	100mA	150mA
Price $	69.95	199	179	219
qty.	1-24	1-9	1-9	1-9

For complete specs on these and our 1- and 2-W models refer to 1985-86 Gold Book or Microwaves directory.

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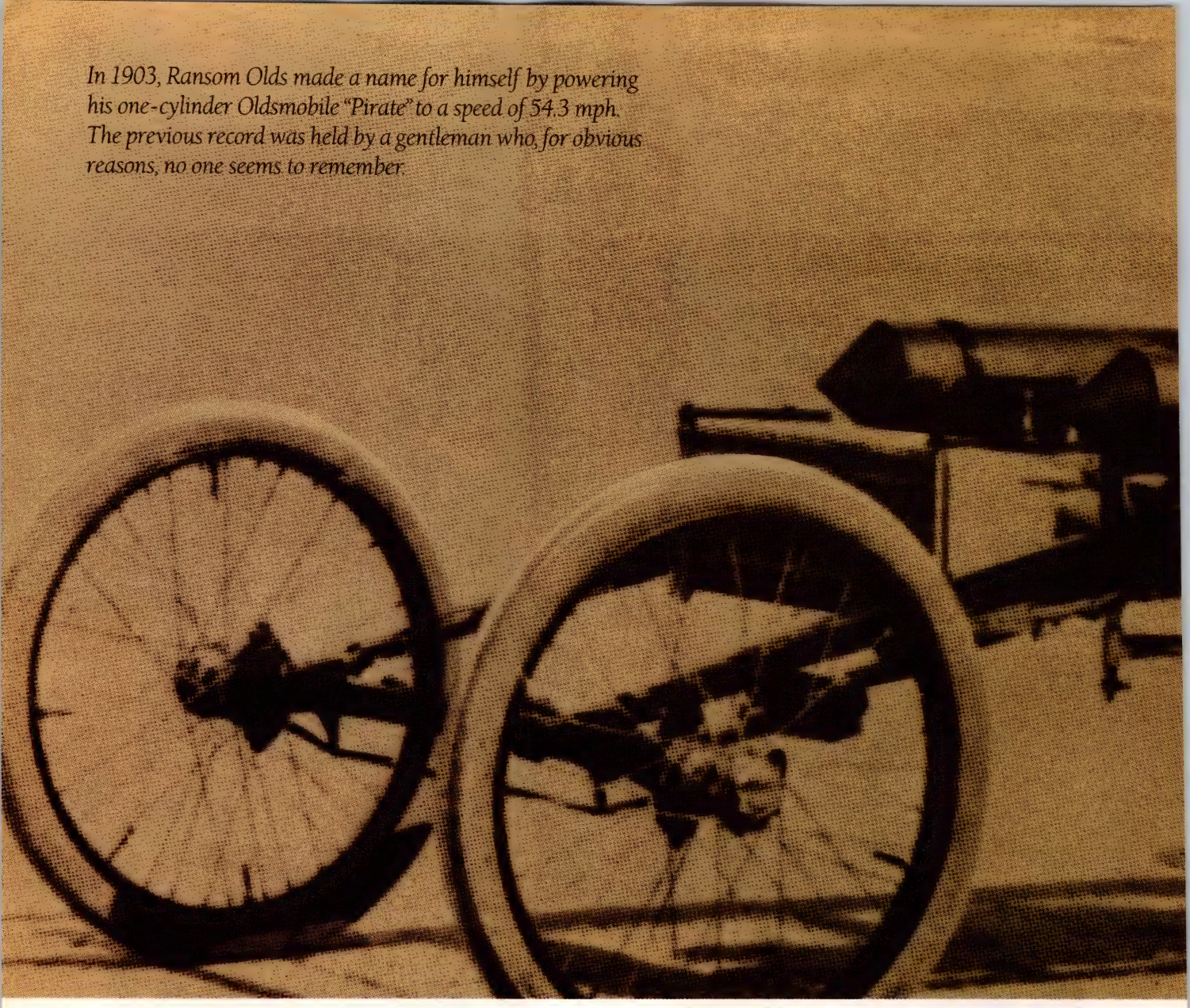
CIRCLE NO 162

C101 REV. A

In 1903, Ransom Olds made a name for himself by powering his one-cylinder Oldsmobile "Pirate" to a speed of 54.3 mph. The previous record was held by a gentleman who, for obvious reasons, no one seems to remember.

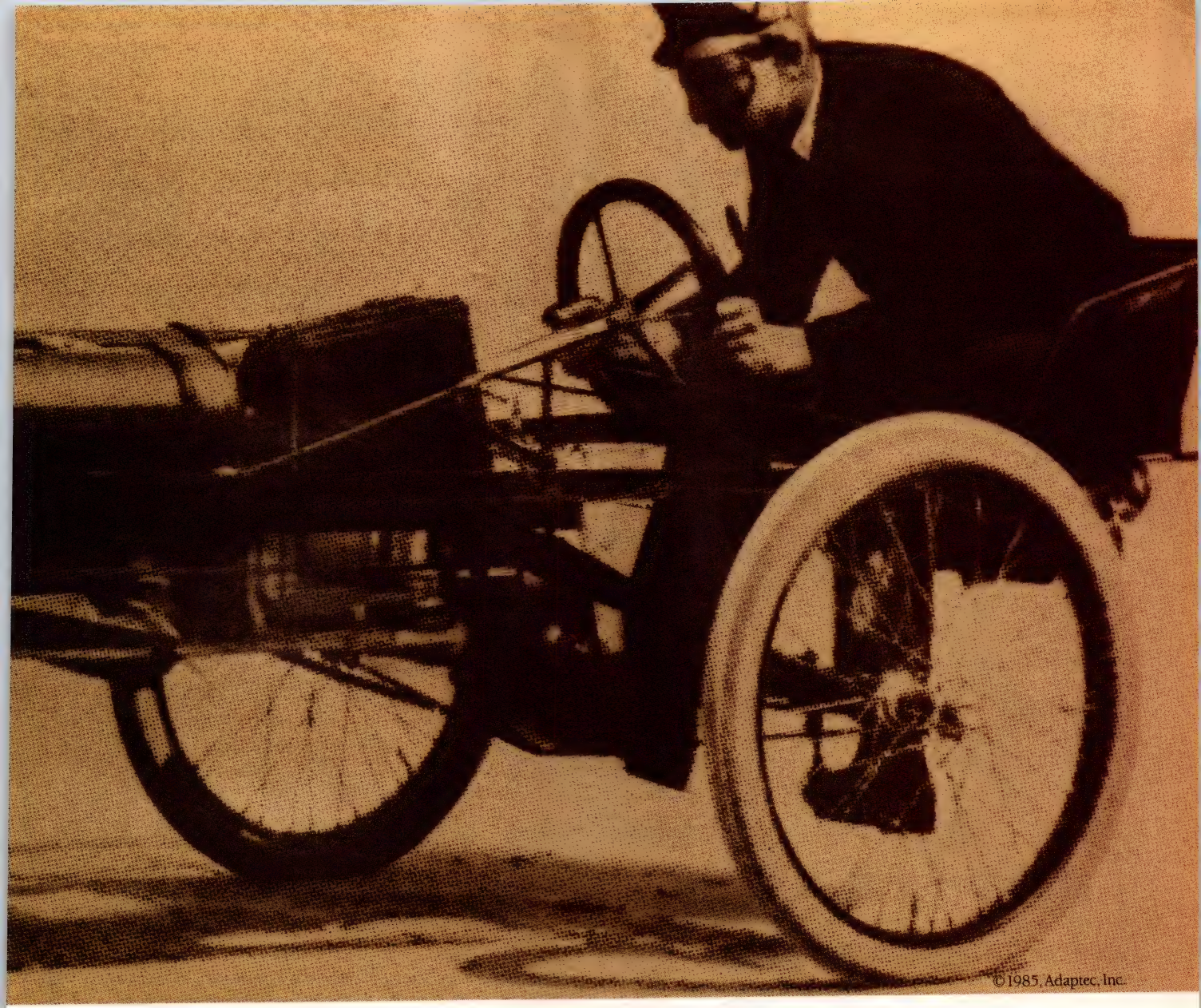


YOU'RE EITHER FAST OR YOU'RE FORGOTTEN.

Engineers have always had a love affair with speed. Whatever they make, they want to make it go faster.

In the computer business, that's especially true. However, building a faster system is not always as simple as adding a faster processor or the fastest drives. It may be some little thing you never think of.

Say, for instance, an I/O controller. And that's what Adaptec is all about.

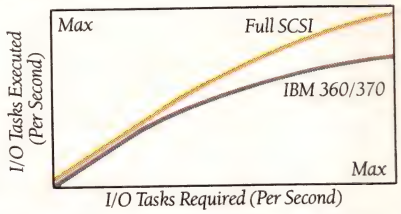


MAINFRAME I/O IN A MICRO.

Adaptec's I/O controllers use an I/O interface derived from mainframes, known as SCSI.

It's our full implementation of SCSI—an industry first—that gives our boards their high performance features.

Like Multithreaded I/O, 1:1 Interleave, Sector Level Defect Skipping and Disconnect/Reconnect.



Adaptec's SCSI controllers can actually outperform a mainframe.

Put them all together and your system can run concurrent I/O tasks with increased data transfer rates and faster access to data.

And that can boost the throughput of your entire system by as much as five times. Even in SMD applications.

So whether it's a low-cost, single-user micro you have in mind or a multi-tasking, multi-user system, we have the controller to help you and your system work faster.

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CIRCLE NO 37

adaptec

SIGNALS & NOISE

No boundary between analog and digital design

Dear Editor:

It was nice to see, from Rick Nelson's editorial "Special Issues: Holistic Technology," (EDN, May 29, pg 45), that someone understands that there really is no boundary between analog and digital design. For many years I have held the belief that the differences between the disciplines are very minor.

Further, I believe that the differences between hardware and software are also very minor. I have been developing custom data-acquisition systems for a number of years and have been forced to cross the boundaries between hardware and software to complete a project.

Analog/digital, hardware/software, high-level language/assembly language—these are all self-imposed boundaries that many people refuse to cross. I believe that the boundaries between the various disciplines do not really exist, but are created for various reasons of human behavior.

When I hear the common analog/digital arguments, therefore, I am amazed that so many people continue to imagine that any significant difference exists between the two disciplines.

Sincerely yours,
David Shear
Shear Engineering
San Diego, CA

"KEEP LOOKING! THERE'S A MISSING DECIMAL POINT IN YOUR SOFTWARE!"

Ground-plane donut pads

Dear Editor:

In the Design Idea entitled "Circuit and ground plane share one surface" (EDN, March 6, pg 260) by N Balakrishnan, the author indicated that the ground-plane donut pads represented in **Fig 1b** of the article were available from Bishop Graphics. The three donut pads shown in the Design Idea are not available from Bishop as regularly stocked items, although we can produce them by special order. The ground-plane

0.8 MICRON FULL CMOS

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PACE TECHNOLOGY is **P**erformance **A**dvanced **C**MOS **E**ngineered to use 0.8 micron effective channel lengths to create internal loaded gate delays of 500 picoseconds. That's at fan in=fan out=4 at 85°C. (Other manufacturers usually quote a ring oscillator delay; if we did this, we could claim 200 picoseconds.) Flip flops toggle at over 250 MHz. PACE TECHNOLOGY includes two-level metal and epitaxial substrates; it exceeds all of the technical objectives of the DOD VHSIC Phase I Program.

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Have others told you they have 0.8 micron technology? Ask them what their metal pitch is. (This is the design rule that separates the men from the boys in VLSI technology.) Ours is 2.75 microns.

SUPERFAST VLSI PERFORMANCE

Few products have challenged the capabilities of a new technology more than our family of Full CMOS Super Fast 64K SRAMs with over 400,000 transistors. Our first 64K SRAM is a 16Kx4 design with 20ns access time, at 70°C and 4.5 volts—worst case. And, our 40 MHz 16-bit processor, the PACE 1750A, has over 200,000 transistors, a 0.6μs integer multiply, and an on-chip floating point with a 1.1μs 32-bit floating point multiply.

40MHz 16-bit processor with a 32-bit floating point on the same chip

These are supported by our family of CMOS Octals for bus interfacing, which are faster than advanced Schottky TTL!! And now, for the first time ever, you can get CMOS with this speed and bipolar driving capability to 64ma for buffers and transceivers.

Our Sunnyvale plant has the world's only Class Two facility for Six-inch wafers. It is 100% dedicated to the manufacture of our products using PACE TECHNOLOGY, and we have already shipped the first parts for revenue in 1985.

Tom Longo, President
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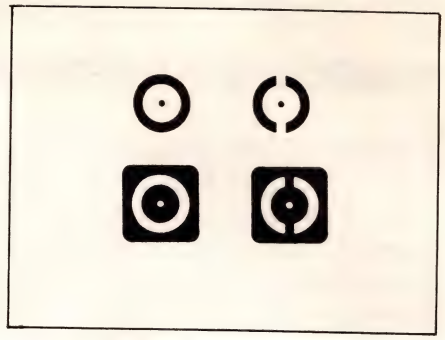

donut pads that we do stock are shown in the accompanying illustration.

Sincerely yours,
Fred H Kern
National Sales Manager
Bishop Graphics Inc
Westlake Village, CA

Corrections

In the manufacturers box accompanying the Special Report on pressure sensors and transducers in EDN's May 1 issue (pg 100), the address for Foxboro/ICT is incorrect. The correct address is Foxboro/ICT, 169 River Oaks Parkway, San Jose, CA 95134. Phone (408) 946-9630.

The phone number for Sensotec Inc is also incorrect as listed. Sensotec can be reached at (614) 486-7723.

Further, the article "Innovative designs yield small, efficient switchers," which begins on pg 223 of the same issue, contains an error. In **Fig 1** (pg 224), the jumper labeled "19 to 75V" should instead be labeled "connect for 19 to 30V."

WRITE IN

Send your letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

FINALLY...a 68000 Development System for Software Developers

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68000 SDS, brought to you by LANGUAGE RESOURCES and featuring the NICOLET NICE 68000 emulator, puts the power of costly engineering workstations and mini computers into the PC. The development tools are the style and quality found on mainframe computers. The support and service offered by LANGUAGE RESOURCES is unparalleled.

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CIRCLE NO 108

Anti-aliasing enhances measurement confidence. Signal distortion (sample mode only) is shown at high frequencies (top). The peak detect mode displays peak information without signal distortion (bottom).

INTRODUCING TWO DIGITAL STORAGE SCOPES WITH SOME MIGHTY IMPRESSIVE NUMBERS.

From 4K record length to 20 MS/s sampling at 100 MHz or 60 MHz...our two new scopes have just what you're looking for! The 2230 and 2220 are powerful digital storage oscilloscopes—and the first scopes in their class that include non-storage capability to these bandwidths.

You can reference, compare, and analyze waveforms with digital storage convenience, plus the confidence you get with analog measurements. Simply switch to the non-store mode to view the signal that the scope has digitized. Only Tek offers this flexibility to 100 MHz and 60 MHz in affordable scopes.

Enhancing use of the scopes as design and troubleshooting tools are fast sample and hold detector circuits, plus the proprietary peak detect mode. They enable the display of pulses as narrow as 100 ns at any sweep speed—even on a single sweep.

You'll also find such features as post-acquisition expansion and compression, X-Y capability to each scope's storage bandwidth and, for systems use, optional GPIB or RS-232-C interfaces.

Best of all, the 2220 and 2230 are easy to use and afford. And backed by Tek's famous 3-year warranty that includes the CRT. Check the front panels. The controls are familiar, comfortable, easy to identify. Designed to push productivity and minimize training time.

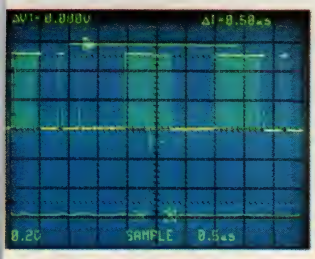
In the 2230, CRT readout of front panel settings and key parameters means even more convenience, with cursors for waveform voltage and timing measurements.

Features	2230	2220
Analog/Digital Storage Bandwidth	100 MHz	60 MHz
Single Shot (Transient) B.W. (10 points per signal period)	2 MHz	2 MHz
Maximum Sampling Speed	20 MS/s	20 MS/s
Record Length	4K/1K (selectable)	4K
Save Reference Memory	One, 4K Three, 1K	One, 4K
Vertical Resolution	8 bit 10 bit (avg mode)	8 bit
Peak Detect	Yes (100 ns)	Yes (100 ns)
Averaging	Yes (menu-selectable)	Yes (rep. sampling)
X-Y Storage Bandwidth	100 MHz	60 MHz
GPIB/RS-232-C Options	Yes (talker/listener, includes 26K of battery-backed memory)	Yes (talker/listener)
Price	$5150	$4150

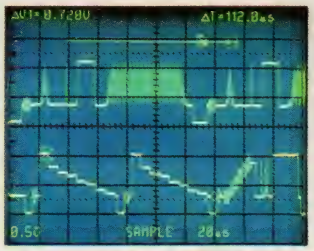
Get the reliability and performance you expect in Tek scopes, now enhanced by digital storage, at unexpected prices: $4150 for the 2220, $5150 for the 2230.

For the full story, and more impressive numbers, contact your local Tek Sales Representative today. Or call the Tek National Marketing Center,

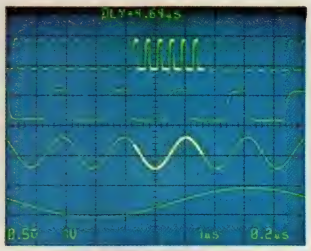
1-800-426-2200.
In Oregon, call collect,
(503) 627-9000.



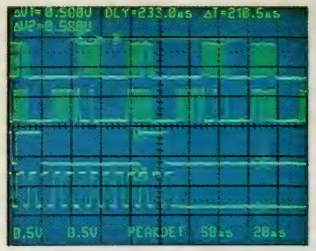
On-screen viewability lets you expand, compress, and position waveforms saved in reference memory. This permits easy viewing and display flexibility of up to eight saved waveforms.



High display resolution and accuracy permits on-screen viewing of signals such as the TV test signal shown here. 4K of record information can be viewed in 1K windows.



100 MHz, non-storage capability comes standard in the 2230. In addition, there's dual channel, dual timebase, versatile triggering and CRT readout.



The 2230 offers the convenience of CRT readout in both storage and non-storage modes at 100 MHz. Storage mode cursors make ΔV, ΔT, and 1/ΔT measurements fast and easy.

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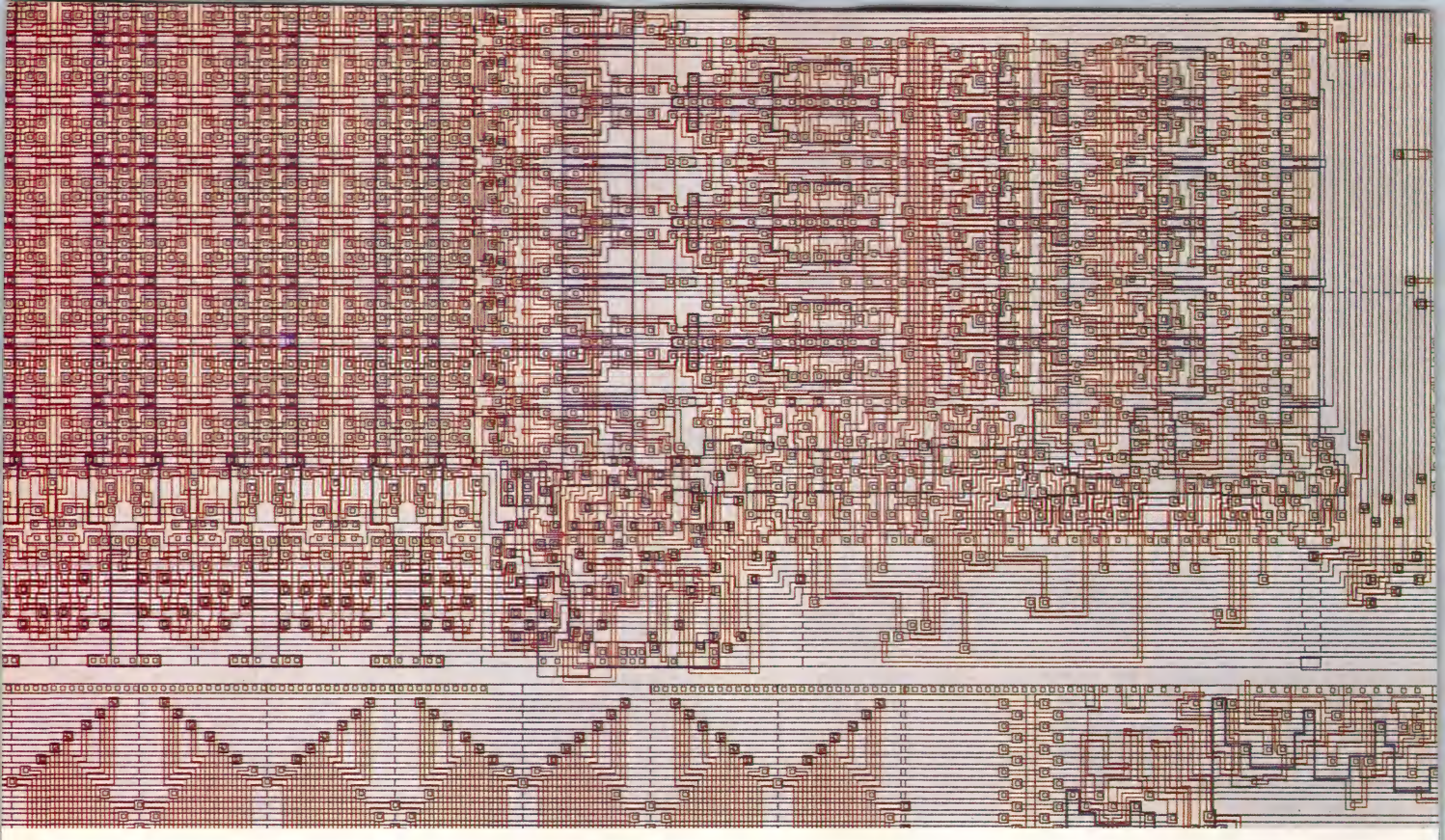
COMMITTED TO EXCELLENCE

CIRCLE NO 167



CALCOMP'S RESOLUTIONARY ADVANCE IN ELECTROSTATIC COLOR PLOTTERS.

Vivid color comes to high resolution electrostatic plotters.

CalComp introduces its new 5800 Series. Resolution is up to four times that of any other color electrostatic plotter—an incredibly sharp 160,000 dots-per-square-inch. The result is better definition, sharper lines and a smoother transition of colors.

Unlike other electrostatic plotters, the 5800 Series features random vector input. This eliminates the need for add-on controllers that take up extra space. And the 5800 provides internal rasterization and color separation to offload the host computer and increase plot throughput.

Registration is unmatched. Our patented electronic system registers each pass without any mechanical adjustment. Simply, there are no moving parts so you are assured of a new standard in accuracy and reliability.

And your maintenance will be minimal due to CalComp's exclusive Enviroclean™ toning system. Extensive diagnostics are built right in. And each plotter is backed by CalComp's worldwide field service network.

For a closer look at these resolutionary plotters, write CalComp, P.O. Box 3250, Anaheim, CA 92803. Or call 1-800-CALCOMP.

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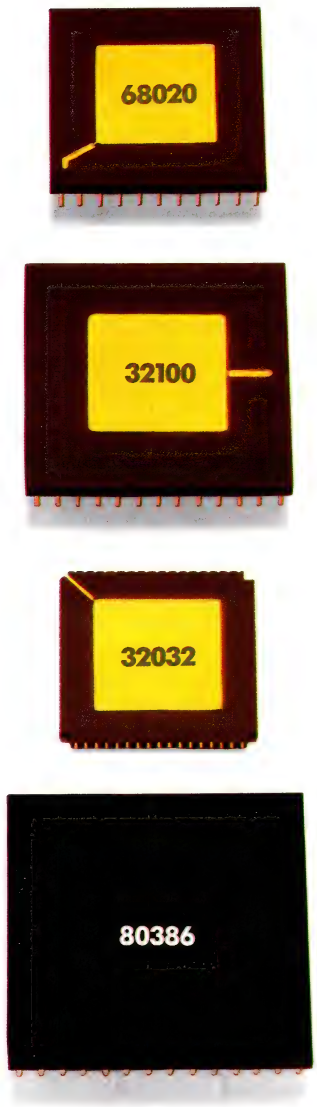
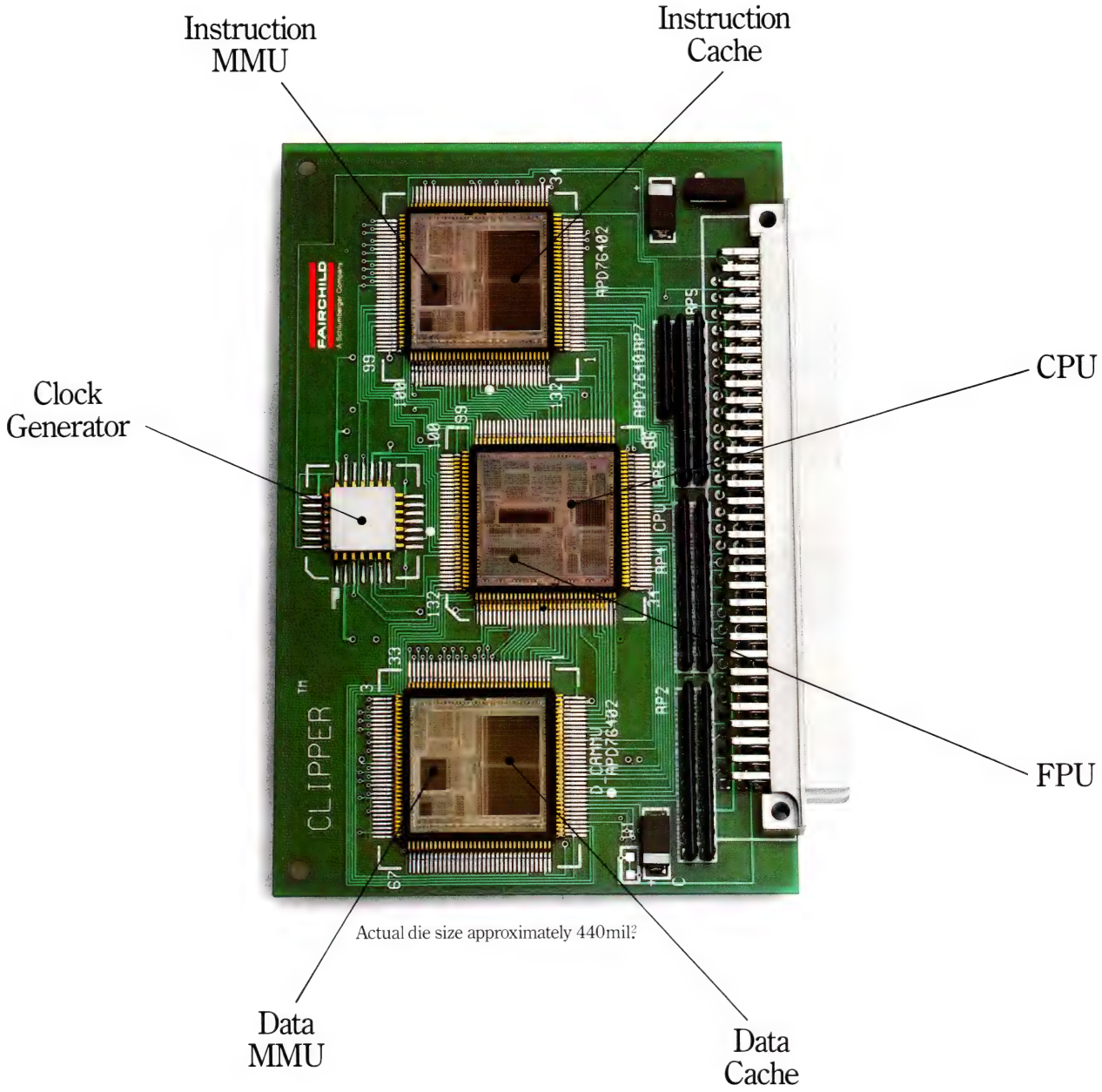
CIRCLE NO 104

If they had it to do all over again,



this is how they'd do it.



Actual die size approximately 440mil²

Fairchild's CLIPPER.™ 33 MHz performance. Today.

Those microprocessors on the first page all talk a lot about being "the most complete," or "ultra-fast," or even "the next industry standard."

Contrary to those claims about being state-of-the-art, however, most of them are actually state-of-the-past. They're all based on architectures developed way back at the dawn of the microprocessor era, and their performance has reached a practical limit. They simply can't bridge the gap to true supercomputer performance.

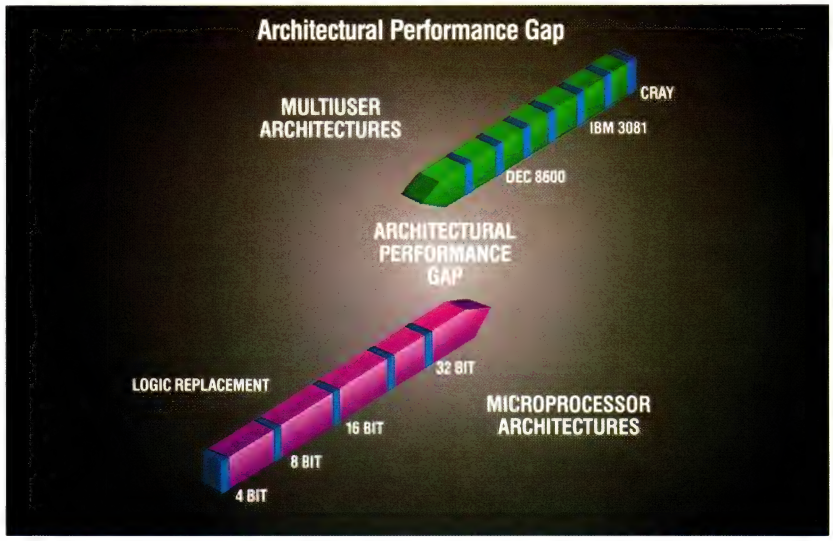
It's high time someone offered something more. Like a microprocessor built from the ground up with a brand new architecture. Able not only to replace those ICs of yesteryear, but to make them obsolete.

Now there's a microprocessor that does just that.

It's called CLIPPER. And it's from Fairchild.

CLIPPER. What everyone else will think of next.

CLIPPER is the biggest single advance in microprocessors since the microprocessor itself. It combines VLSI design with mainframe and supercomputer techniques to create the new standard in 32-bit microprocessor performance. Our CLIPPER port based on the UNIX® System V operating system gives unprecedented software power, speed and portability to any application. And in today's RISC-oriented world, CLIPPER does RISC one better – its unique Streamlined Instruction Set offers all the advantages of a RISC, the advantages of a CISC, and then some.



Just by looking at it, you can tell CLIPPER is a different breed of microprocessor. In a unique three-chip set, you get an architecturally advanced, very high-performance, CMOS 32-bit compute engine, optimized for scientific and professional computing applications. In fact, you get everything in the three CLIPPER chips that it takes the competition's entire CPU board to give you.

The bottom line? CLIPPER is incredibly fast. It's optimized for speed, and designed for high bandwidth and true concurrent execution of instructions. It also runs at 33 MHz which, until CLIPPER proved otherwise, was considered impossible. CLIPPER achieves a peak execution rate of 33 MIPS, with average performance greater than a VAX™ 8600 – twice as fast as any other microprocessor in existence, five *times* as fast as a VAX 11/780. Floating-point performance exceeds 2 MFLOPS, while simple instructions execute in a scant 30 nanoseconds.

bus dedicated to instructions, the other to data.

The two cache chips are identical. The instruction cache is distinguished from the data cache only by the activation of an on-board program counter that allows prefetch activities into cache memory.

The fast caches provide hit rates greater than 90%. And the instruction cache hit rate with prefetch enabled is greater than 96%.

Contributing to this phenomenal access speed is the combination on the same chip of the cache and demand-paged MMU, which reduces bus loading and eliminates chip-to-chip delays. In addition, virtual addresses are translated concurrent with cache access, eliminating the performance bottleneck of virtual memory translation. Separate caches called Translation Lookaside Buffers (TLBs) store 256 recent page translations. These large TLBs improve overall system performance up to 20% over systems with smaller TLBs.

And your program won't be cramped by an insufficient address space.

Each user process enjoys a full 4G bytes of virtual memory, which may be separate from the operating system's 4G-byte virtual address space. Virtual addresses are translated to a 4G-byte real memory space with a separate 4G bytes for each I/0 and boot memory.

More CLIPPER support. Inside and out.

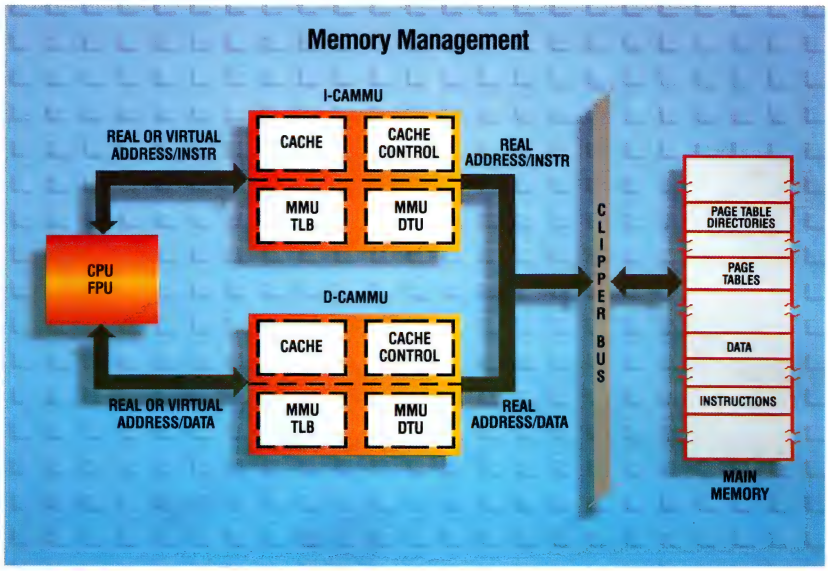
As befits a breakthrough in microprocessor technology, CLIPPER is supported by a powerful software environment. After all, you don't want to spend your time developing software tools. So we give you everything you need, ready-made. Including a CLIPPER port based on the UNIX System V operating system. Optimized FORTRAN, C and Pascal compilers. Plus an assembler.

Or you can choose a VAX cross-support package. Which includes an assembler, C compiler, processor simulator, performance analyzer, debugger, and various other utilities.

There's one more important ingredient in the CLIPPER package: expert advice, care of our application engineers and systems designers. Each one of them, in every sales office and FAIRTECH™ Design Center, thoroughly trained in helping you get everything out of CLIPPER that we put into it. And each one of them ready to help.

CLIPPER. The future got here sooner than you expected.

So there you have it. Simply the most advanced 32-bit microprocessor since the advent of microprocessors themselves.



Offering superior performance advantages in literally every system area: speed, technology, integration, and architecture.

For more information, just give us a call. CLIPPER

You'll find us at The Fairchild Customer Information Center by dialing 1-800-554-4443.

CLIPPER from Fairchild. It's what the competition wishes they'd built in the first place.

We're taking the high ground.

FAIRCHILD

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Think of it as a very small supercomputer.

Unlike any other microprocessor architecture, CLIPPER uses proven supercomputer and mainframe architectural concepts.

Pipelining, for example. Not only do we overlap fetch, decode and execute processing phases, but we've gone one step further to pipeline the integer execution unit, processing up to three instructions at the same time during the execute phase.

Concurrent processing units are also built in: the CLIPPER FPU is on-chip, for faster processing in parallel to integer operations.

We also included mainframe-style caching. The two large 4K-byte caches, combined with mainframe-style set associativity and 16-byte line size, reduce memory access times and significantly improve hit ratios. When it comes to bus bandwidth, the CLIPPER CPU features two 32-bit buses to cache memory. Bus bandwidth to the CPU is 133M bytes per second, far greater than ordinary, single-bus architectures. We enhanced bus bandwidth even further by using an additional 32-bit CLIPPER synchronous bus that provides quad-word updating of the caches, in addition to its flexible byte, half-word and word transfers.

Then there is the distinctive CLIPPER Streamlined Instruction Set. 101 instructions are hardwired instead of microcoded to deliver the performance of a reduced instruction set computer. We balanced the RISC architecture by adding a macro-instruction unit. Which provides 67 high-level instructions and functions such as floating conversions, task switch, trap and interrupt handling. And the CLIPPER resource manager provides instruction pipeline management in hardware, where you want it, instead of in your software tools. The result? You get all the advantages of a RISC with the robustness of a complex instruction set.

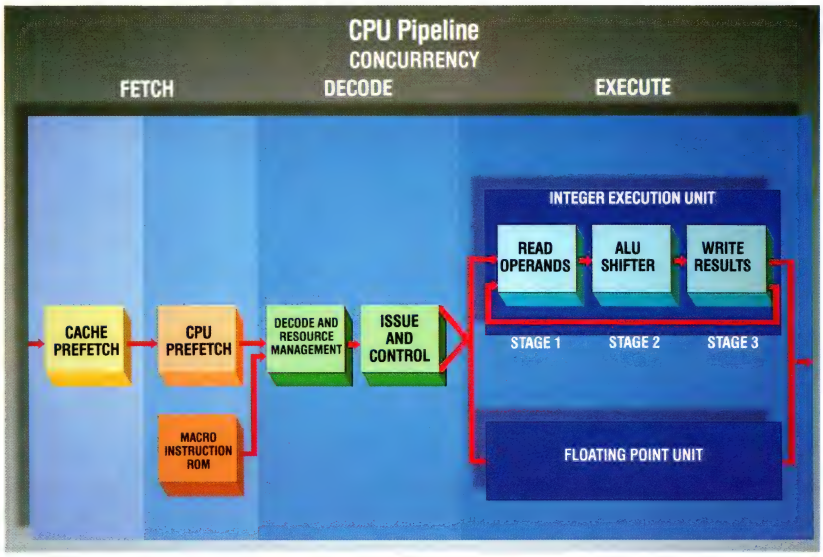
What got into CLIPPER.

The revolutionary CLIPPER three-chip module resides on a 3.0 x 4.5-inch printed circuit card which interfaces to your system with a standard 96-pin connector. You'll find a pipelined CPU with a three-stage integer execution unit, plus an on-chip, IEEE-standard floating point unit. For packaging, we put the chips in state-of-the-art 132-pin ceramic leaded chip carriers.

Next you'll find two 4K-byte combination cache/memory-management chips. A clock generator completes the package, for a staggering total of 846,000 transistors. That's practically as dense as all the competition put together.

Lastly, you'll find switching speeds up to the rest of the fast CLIPPER standards. Like Fairchild's FACT logic family and other advanced products, CLIPPER is fabricated with a high-speed, double-metal advanced CMOS process that achieves transistor switching at speeds of up to 500 ps.

If you're having trouble keeping up with speeds like this, just think how the competition feels.



Our cache is right on the money.

In keeping with our goal of bringing supercomputer technology to the chip level, we linked the CLIPPER cache chips via a dual-bus architecture, with one 32-bit

Here's where to find it.

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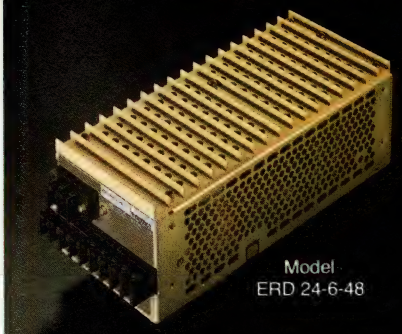

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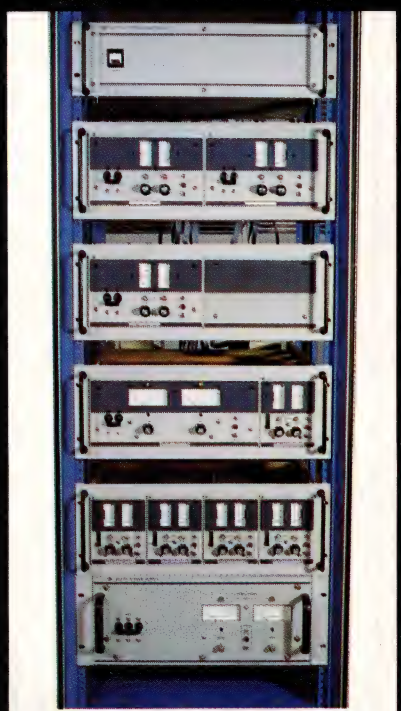

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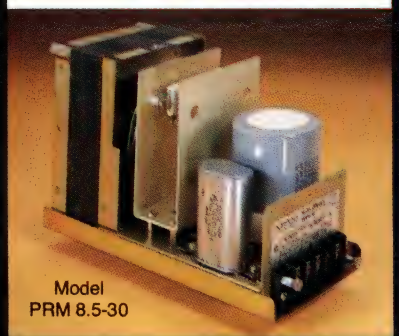

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CALENDAR

Siggraph '86 (13th Annual Conference on Computer Graphics and Interactive Techniques), Dallas, TX. Smith, Bucklin & Associates, 111 E Wacker Dr, Chicago, IL 60601. (312) 644-6610. August 18 to 22.

3rd International Congress on Advances in Nonimpact Printing Technologies, San Francisco, CA. Society of Photographic Scientists and Engineers, 7003 Kilworth Lane, Springfield, VA 22151. (703) 642-9090. August 25 to 28.

8th Quartz Devices Conference, Kansas City, MO. Electronic Industries Association, Components Group, 2001 Eye St NW, Washington, DC 20006. (202) 457-4930. August 26 to 28.

Advanced Database Symposium, Tokyo, Japan. Information Processing Society of Japan, Kikaishinkou Kaikan, 3-5-8 Shiba Park, Minatoku, Tokyo 105, Japan. August 29 to 30.

World Computer Congress, International Federation for Information Processing (IFIP '86), Dublin, Ireland. David Hyatt, Data Decisions, 20 Brace Rd, Cherry Hill, NJ 08034. (609) 429-7100. September 1 to 5.

Comdex/Australia, Sydney, Australia. Interface Group, 300 First Avenue, Needham, MA 02194. (617) 449-6600. September 2 to 5.

IEEE Eascon '86 (IEEE Electronics and Aerospace Systems Conference), Washington, DC. Eascon '86, Suite 300, 655 15th St NW, Washington, DC 20005. September 8 to 10.

NCC-Telecommunications Conference, Philadelphia, PA. AFIPS, 1899 Preston White Dr, Reston, VA 22091. (703) 620-8900. September 8 to 10.

IS YO R EMU ATOR G VING YOU THE WH LE P CTURE?

Probably not.

Unless it's an in-circuit emulator from Sophia Systems.

You see, with our emulators, you can test in real time all the time—without wait states—even during memory access.

And that's important.

Because every time your emulator inserts an unnecessary wait state, you end up testing pieces of code. Instead of your system as a whole.

Fortunately, Sophia Systems can help fill in all the gaps. With special features and functions that other emulator makers still haven't matched.

For instance, our emulators let you map your system's I/O and memory in real time. Which means you can emulate the exact environment in which your software will run.

Rather than approximate it.

Next, there's our Trace Buffer. At 4K by 32 bits, it holds code, memory and bus status information. So you can capture a wider view of what's happening and when. Both before and after a fault occurs.

And, with as many as 24 breakpoints at your command, you can stop the action more often. Which can save you hours of looking through line after line of code.

To complete the picture, Sophia Systems offers all the tools you need in one powerful piece of equipment. So you don't have to buy a separate PROM burner, display monitor and keyboard to do your debugging.

And as if that weren't enough, Sophia Systems' emulators support more microprocessors than any other universal emulator. Microprocessors from Intel, NEC, Hitachi, Motorola and more.

So for a demonstration or more information, call **800/824-9294**. In California, call **800/824-6706**.

And see what you've been miss ng.

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CALENDAR

Midcon, Dallas, TX. Electronic Conventions Management, 8110 Airport Blvd, Los Angeles, CA 90045. (213) 772-2965. September 9 to 11.

Modern Electronic Packaging, Santa Clara, CA. Technology Seminars, Box 487, Lutherville, MD 21093. (301) 269-4102. September 9 to 11.

International Videotex Industry Exposition and Conference, New York, NY. Videotex Industry Association, 1901 N Fort Myer Dr, Suite 200, Rosslyn, VA 22209. (703) 522-0883. September 15 to 17.

Printed Wiring Board Assemblies —Processes, Techniques, and Equipment (short course), Milwaukee, WI. Peter Tocups, Center for Continuing Engineering Education, University of Wisconsin-Milwaukee, 929 N 6th St, Milwaukee, WI 53203. (414) 224-3952. September 15 to 17.

Euromicro '86 (Symposium on Microprocessing and Microprogramming), Venice, Italy. Euromicro, Box 217, 7500 AE Enschede, The Netherlands. 31-53-33 87 99. September 15 to 18.

Modern Power Conversion Design Techniques (short course), Santa Clara, CA. E/J Bloom Associates, 115 Duran Dr, San Rafael, CA 94903. (415) 492-8443. September 15 to 19.

5th Annual Conference of the American Voice I/O Society, Alexandria, VA. American Voice I/O Society, Box 60940, Palo Alto, CA 94306. (408) 742-2539. September 16 to 18.

Fall National Design Engineering Show and Conference, New York, NY. Cahners Exposition Group, 999 Summer St, Stamford, CT 06905. (203) 964-0000. September 16 to 18.

Power-One Has Good News And Great News

ncomparable Power-One Quality

Exacting Workmanship Standards

Tough Double Test & Burn-in

CAE/CAD Designs

Extensive R&D Investment

Thick Film Hybrid Technology

The Good News is What We Put Into Our Power Supplies

MIL-I-45208A Inspection Program

Advanced Circuit Technology

Proprietary Production Processes

Total Vertical Integration

Large Volume Production

MIL-Q-9858A Quality Program

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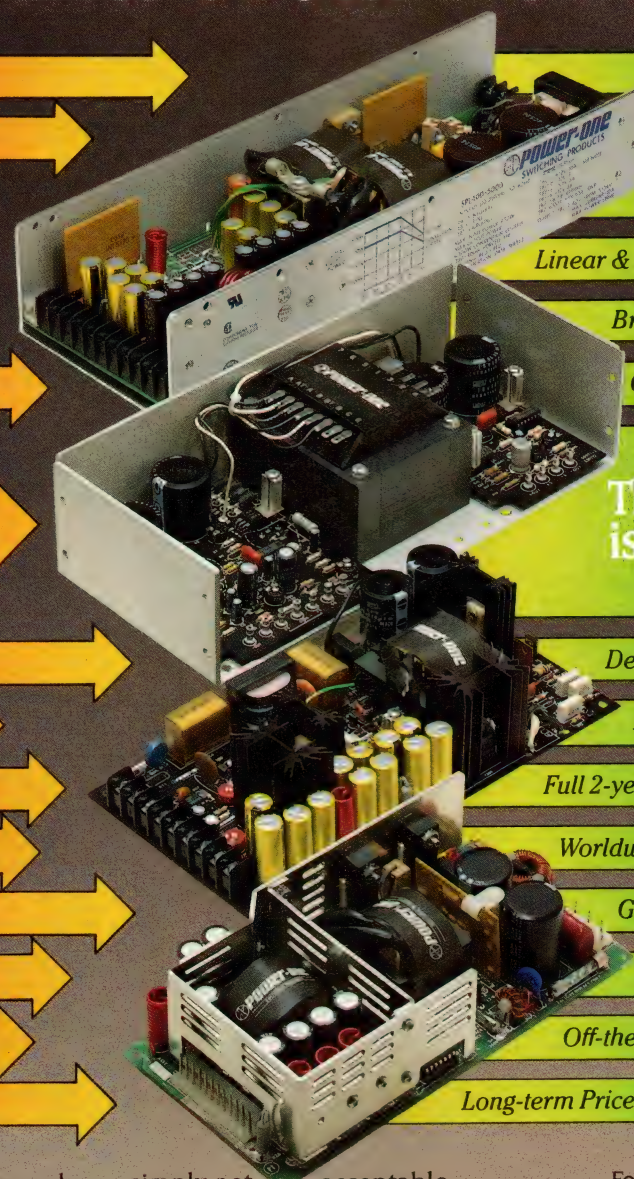
Experience — Over 4 Million Sold



Value...Service...Economy

Trouble-free Performance

Worldwide Product Acceptance

Linear & Switching Technologies

Broadest Standard Product Line

Custom Design Capabilities

The Great News is What You Get Out

Demonstrated High Reliability

International Safety Approvals

Full 2-year Warranty

Worldwide Distribution

Guaranteed Customer Satisfaction

Large Inventories Worldwide

Off-the-shelf Delivery

Long-term Price Stability

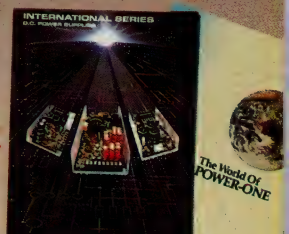
The old axiom that "you only get out what you put in" is as true with power supplies as with any other electronic equipment. At POWER-ONE we know what our customers expect. That's why we've held fast to our commitment to excellence throughout the years. And why maximum reliability is virtually synonymous with every power supply we produce.

Our modern production techniques, combined with the latest design and manufacturing innovations, have resulted in a line of power supplies of the highest possible quality. Anything less is simply not acceptable... either to you or to us.

So whether your requirements call for switchers, linears, or customs, you can always expect top performance from POWER-ONE. With over 200 standard models to choose from, you'll get the exact power supply you need. Plus consistent POWER-ONE quality that does the job, time after time. And at prices that are the most competitive in the industry.

So let our good news and great news add up to the *best news* of all for you — the absolute certainty that when you specify POWER-ONE, you've selected the best!

For the complete POWER-ONE story and new 1987 Catalog: **CALL OUR TOLL-FREE LITERATURE HOT-LINE TODAY: (800) 235-5943, Ext. 113. From CALIFORNIA: (800) 421-3439, Ext. 113.**



"Innovators in Power Supply Technology"

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POWER-ONE D.C. POWER SUPPLIES
740 Calle Plano • Camarillo, CA 93010-8583
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Now RCA drives CMOS

into the FAST* lane.

Advanced CMOS Logic: the new industry standard that's fast as FAST.

Now, Advanced CMOS Logic (ACL) gives you speed and drive to match FAST. You get all the advantages of CMOS, with less than 3ns propagation delay (AC 00 NAND Gate) and 24mA output drive current.

Pin-compatible with other ACL brands.

Our family of ACL types sets a new industry standard. When other manufacturers who have announced ACL begin production, they'll be performance and pin-compatible with RCA.

Outperforms FACT.*

Our ACL is faster than FACT. RCA ACL uses a 1.5 micron channel length N-well CMOS process resulting in an on-chip gate delay of only 0.7ns.

FAST speed, CMOS low power.

ACL power dissipation is typically less than 25% of a FAST bipolar device. ACL dissipates less than a quarter of one Watt while switching, compared to one full Watt for a FAST IC (transceiver operating at 5 MHz). Quiescent power savings are even more dramatic. ACL idles at 1/1000 the power of a FAST IC (.5μW vs. .5W).

And with lower heat dissipation than bipolar, you can expect ACL to perform more reliably than FAST and AS.

Latch-up and ESD Protection.

Latch-up concern is virtually eliminated. ACL uses a thin epitaxial layer which effectively shorts the parasitic PNP transistor responsible for SCR latch-up.

And new dual diode input/output circuit provides ESD protection in excess of 2KV.

High Rel and macrocells, too.

Most ACL designs from RCA will be available in our macrocell library for standard cells. And we'll have High Rel versions screened to MIL-STD-883 Class B coming soon.

80 types in 1986.

Our initial release includes ten of the most popular types, where speed is most important to you.

By year end, our line will consist of ten SSI parts, 56 MSI parts and 14 LSI parts in both AC and ACT (TTL-compatible) versions.

Prices comparable to FAST.

Our ACL line is priced comparably to FAST, so your savings with CMOS low power pay for the cost of switching.

Start your sampling today.

Put yourself ahead in the technology race by calling your RCA sales office for samples today. Or write RCA Solid State, Box 2900, Somerville, NJ 08876.

*FAST and FACT are trademarks of Fairchild Semiconductor Corp.

RCA

Reader Vote No. 9006


Kalish

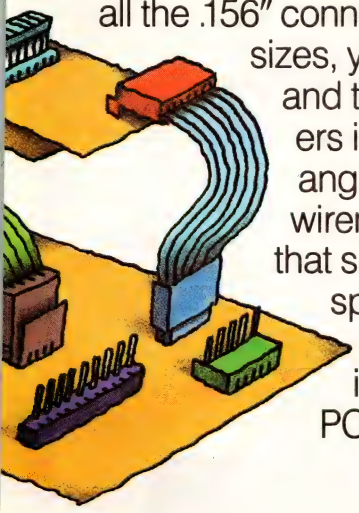
Too many components from too many vendors can breed mass confusion.

With 3M's broader line, you're covered.

If you're spending more time cross-checking spec sheets than doing your real job, you're wasting precious design time.

So 3M is adding our new Modular Connector System—MCS—just for you. The new MCS family broadens our range of PWB connectors and cables, and lets you specify 3M reliability for more applications than ever before. MCS nylon and polyester components feature a variety of contact materials, for both .156″ and .100″ applications.

Now you can specify our new MCS components for an entire array of .156″ connector applications: MCS board-mount and wiremount sockets that feature our patented L/H contacts; headers in straight and right-angle solder tail designs, mass terminating card-edge connectors, plus a full complement of mating ribbon cables. Your .100″ connector applications are covered, too. In addition to offering all the .156″ connector styles in .100″ sizes, you can also get one and two row pin strip headers in straight and right-angle designs; stackable wiremount PCB connectors that save valuable board space; a selection of cables with .100″ spacing; shunts that change PCB circuits without DIP switches; and flex circuit connectors in straight or right-angle designs, to help you make connection to flat-conductor flat cable.



3M even makes sure you get exactly the connector you need by letting you specify variations such as connector body material, plating thickness, pin density, etc. for our MCS components. So you virtually eliminate the risk of ordering components with the wrong specs.

Our new, broader line of MCS components is backed by The 3M Risk Reduction Plan. It helps cut scheduling and design risks by getting you the connectors and reliable specs you need, when you need them. It helps you get quick answers to your questions from a 3M sales representative, or the Technical Service Engineer who answers our toll-free product information hotline (1-800-328-7732). And, best of all, it's supported by our nationwide network of 3M distributors.

For the specifics on our new, broader line of quality 3M connectors, call your 3M Distributor. Or write Electronic Products Division/3M, P.O. Box 2963, Austin, TX 78769-2963.

3M hears you...

3M

CIRCLE NO 52

Count on OKI to expand your CMOS CSIC options.

Gate Arrays

1.5-micron & 2-micron 70V000 Series VERY HIGH SPEED		1.5-micron & 2-micron 70H000 Series HIGH SPEED		3-micron 70000 Series	
# Gates	# I/Os	# Gates	# I/Os	# Gates	# I/Os
700	66	3289	86	387	44
1000	66	4290	104	720	62
1500	66	6000	130	1445	88
2000	80	8024	148	2000	106
2500	80	10008	172	4205	120

NOW: Expanded Gate Array options from OKI, supported by world-class CSIC capabilities.

Expanded product families and packaging. For more cost-effective, more flexible single-chip logic integration, OKI supplies more pre-designed Gate Array options—in the most advanced package types: plastic or ceramic through-hole DIPs or pin grid arrays; or plastic surface-mount PLCC or flatpack.

Expanded services, plus world-leading production automation. OKI CSIC* design expertise is accessible at any development stage. And OKI's CSIC manufacturing/testing facilities—among the world's most highly automated—assure high quality, high volume fabrication.

Reader Vote No. 9004

For RFQ or technical data, complete form below and return to: CSIC Marketing, OKI Semiconductor, 650 N. Mary Ave., Sunnyvale, CA 94086. (408) 720-1900.

*Customer-Specific Integrated Circuit

RFQ

Request for Quote

OKI CMOS Gate Arrays

For prompt response to your Request for Quote (returned with complete technical data), please fill out these brief specifications.

OKI SEMICONDUCTOR

My application requires:

1. Gate count: _____
2. Pin count: _____
3. **CMOS process:**
   - ( ) 1.5 micron
   - ( ) 2 micron
   - ( ) 3 micron
4. **Packaging preferred:**

   Surface-mount
   - ( ) PLCC
   - ( ) Flatpack

   Through-hole
   - ( ) Pin Grid Array
   - ( ) DIP
5. **Anticipated volume:**

   _____ pieces/month

☐ Please call me for immediate consultation.

Request for Data

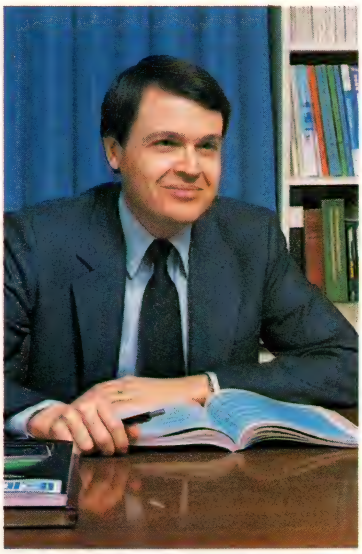
☐ Please rush complete technical input on:
- ( ) CMOS Gate Arrays
- ( ) CMOS Standard Cells
- ( ) CMOS Custom VLSI Logic

Name/Title _____ Company _____ Tel: (___) _____

Address _____ City _____ State _____ Zip _____

EDN

Pick a winner



Selecting the right products for your designs is one of the most important aspects of your job. It can even be as important as the design activity itself, because the right product can enable you to create a design that's not otherwise possible, or a design that's simply far more elegant than its alternatives.

Sifting through all the available products, though, can be an endless job—something few designers and design managers have time for. Consequently, many of you turn to design publications like EDN for help. Our editors, and the editors of similar publications, try to distinguish the best products from all those introduced and to make the most essential information available to you. Now, we're taking that process one step further, giving you and your colleagues a chance to help each other in your quests. How? By enabling you to make known *your* selections of the best new products.

Beginning with this issue, on pg 131, we're presenting a new feature, called Readers' Choice. We call it that because it's a list of the most interesting new products as judged by you, our readers. In this particular issue, we present the "winners" from products that appeared in our May 29 issue's New Products and Product Update sections. You "voted" for your favorites when you requested additional product information by circling numbers on our Information Retrieval Service card. We've monitored your responses, and now that the trends are clear, we're publishing the results. There's a winner for each of six different product categories.

We can't guarantee, of course, that you'll always find what you're looking for in Readers' Choice. What we can guarantee is that each product in the list is important in the minds of many of your colleagues. We thank you for picking these winners; we hope you'll thank us when you use them in your designs.

Gary Legg

Gary Legg
Editor

WEEK 41

Usually there are lots of IC sources. With a new chip, though, there may be only one place to find it.

Until today, that's been the case with NCR's 5380 SCSI Peripheral Interface. Not anymore. Introducing AMD's 5380 SCSI Peripheral Interface. Strangely enough, it's just like NCR's. As a matter of fact, it's a plug-in replacement. (NCR's meets the ANSI Standard Committee X3T9.2. So does ours.)

5380

To have and have not.

But AMD's 5380 comes with something no one else can offer: It's the International Standard of Quality. It makes a very big promise that we keep with the 5380 and every other IC we sell. We guarantee a 0.05% AQL on all electric parameters, AC and DC, over the entire operating range. Because we think it's no use having the 5380 or any other part if it doesn't come with a promise that means something.

The 5380 with INT•STD•500. Only from AMD.

CIRCLE NO 177

WEEK 42

AMD not only lets you beat the clock. It lets you program it your way. From delay lines to system timing. All with one very timely device: AMD's new Am2971 Programmable Event Generator.

You'll have your choice of twelve independent registered output waveforms. You'll be able to set, stop and start functions. You can schedule events down to 10ns.

Am2971

Beat the clock.

And here's your chance to stop hassling with delay lines. The Am2971 is a programmable solid state substitute. And all its functions are programmed as easily as a PROM.

To keep everything in sync, the Am2971 lets you set your own system clock, too. For accuracy, there's a multiplying phase-locked-loop oscillator. Or clock it from an external source.

When you set the timings just the way you want, you can make your system perform better. That's why we made the Am2971. Because at AMD, we know that timing is everything.

CIRCLE NO 196

WEEK 43

Don't get us wrong. TRW's bipolar 12 X 12-Bit Multiplier Accumulator is a very serviceable product.

But when AMD decided to become a second source for the TRW TDC1009J we started by doing all the usual stuff. The Am29C509 is a plug-in replacement for the TDC1009J. Both have the same multiplier and adder in one space saving package. Both have Round Control as well as 27-Bit Product Accumulation Result to give you the luxury of extra headroom.

Am29C509

How to make a silk purse out of a sow's ear.

The similarities end there. We designed the Am29C509 in CMOS so it doesn't hog power. In fact, power needs are cut by 85%. And it gives twice the performance. Our multiply accumulation time is 70ns.

The moral to the story is that the best TDC1009J is our Am29C509; the silk purse with the built-in sow's ear.

CIRCLE NO 178

Advanced Micro Devices • **Bruxelles** (02) 771 99 93 • **Hannover** area (05143) 50 55 • **Hong Kong** (0852) 3-695377 • **London** area (04862) 22121
Manchester area (0925) 828008 • **Milano** (02) 3390541 • **München** (089) 4114-0 • **Paris** (01) 46.87.36.66 • **Stockholm** (08) 733 03 50 • **Stuttgart** (0711) 62 33 77
Tokyo (03) 345-8241 • **Latin America, Fort Lauderdale, Florida/U.S.A.** Tel: (305) 484-8600 Tlx: (510) 955-4261 amd. ftl

WEEK 44

Our new Am8159 Three-Gun Graphics Color Palette is all you need to turn a dull lifeless system into one with exciting color graphics. Out of a total of 4096 colors, you can create a graphics palette of 64 colors.

Am8159

Help for the colorless.

The Am8159 puts three 4-bit video DACs and a 64 x 13 RAM color map all on a single chip. That means better, more efficient performance. There's an on-chip Address Multiplexer which supports Video Address pins for the graphics mode. And System Address pins for the look-up table.

Whether you're working with a 16-bit or 8-bit system, the Am8159 delivers greater flexibility in your system performance. And with an 83 MHz pixel data rate, you'll get high resolution.

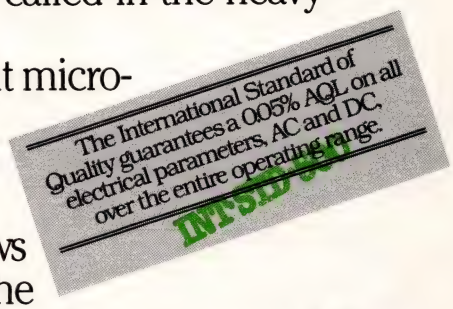
The Am8159 is just part of our complete system solution of bit-mapped graphics. So whatever system you're designing, turn to us for the solutions you need to put a lot of color in your life.

CIRCLE NO 197

Advanced Micro Devices has broken the game wide open.

After building a comfortable lead with a new product a week, every week—on the shelf, in volume—we called in the heavy hitters:

ISDN. CMOS. 32-bit microprocessor chip set. High-speed RAMs. Modems.



No one who follows the game closely is the least bit surprised. This team puts more dollars into R&D, as a percent of sales, than anyone else in the business.

If you like the sound of extra bases, call Advanced Micro Devices.

Advanced Micro Devices

For more information, contact the sales agent nearest you or write the word "Forty-four" on your letterhead and mail to Advanced Micro Devices, Mail Operations, P.O. Box 4, Westbury-on-Trym, Bristol BS9 3DS, United Kingdom.

REMEMBER WHEN THE CHIPS WERE DOWN?

Your system, or maybe even your entire line, was down. The chips you ordered didn't meet spec, quantities were insufficient, or maybe they weren't produced at all. It's a hair-raising experience.

INMOS understands how you feel. That's why we're dedicated to the highest standards of quality and reliability, without compromising performance in any of our products: SRAMs, DRAMs, Microcomputer products or ASICs.

For example, our CMOS Static RAMs have quality levels better than 300ppm and reliability levels below 50 fits. This means with 16 of our 16K SRAMs, your cache memory should have better than 100 years of failure-free performance.

We know the stakes are high. At INMOS, you get products you can depend on from a company you can depend on.

16K CMOS SRAMs	
Device	Access Times
IMS1403 (x1)	20, 25, 35, 45ns
IMS1423 (x4)	23, 35, 45ns

64K CMOS SRAMs	
Device	Access Times
IMS1600 (x1)	35, 45, 55ns
IMS1620 (x4)	35, 45, 55ns
IMS1624 (OE, x4)	35, 45, 55ns
IMS1630 (x8)	45, 55, 70ns

LOW POWER DATA RETENTION CMOS SRAMs		
Device	Access Times	Idr*
IMS1403L (x1)	25, 35, 45ns	0.5μA
IMS1601L (x1)	45, 55, 70ns	10μA
IMS1620L (x4)	45, 55, 70ns	10μA
IMS1624L (OE, x4)	45, 55, 70ns	10μA

All above products are available in MIL-STD-883C. *Idr = Typical Icc at 2V at 25° centigrade. inmos, and IMS are trademarks of the INMOS Group of Companies.

CMOS STATIC RAMs

inmos®

INMOS, Colorado Springs, Colorado, Tel. (303) 630-4000;
Bristol, England, Tel. 272-290861;
Paris, France, Tel. (14) 687-2201;
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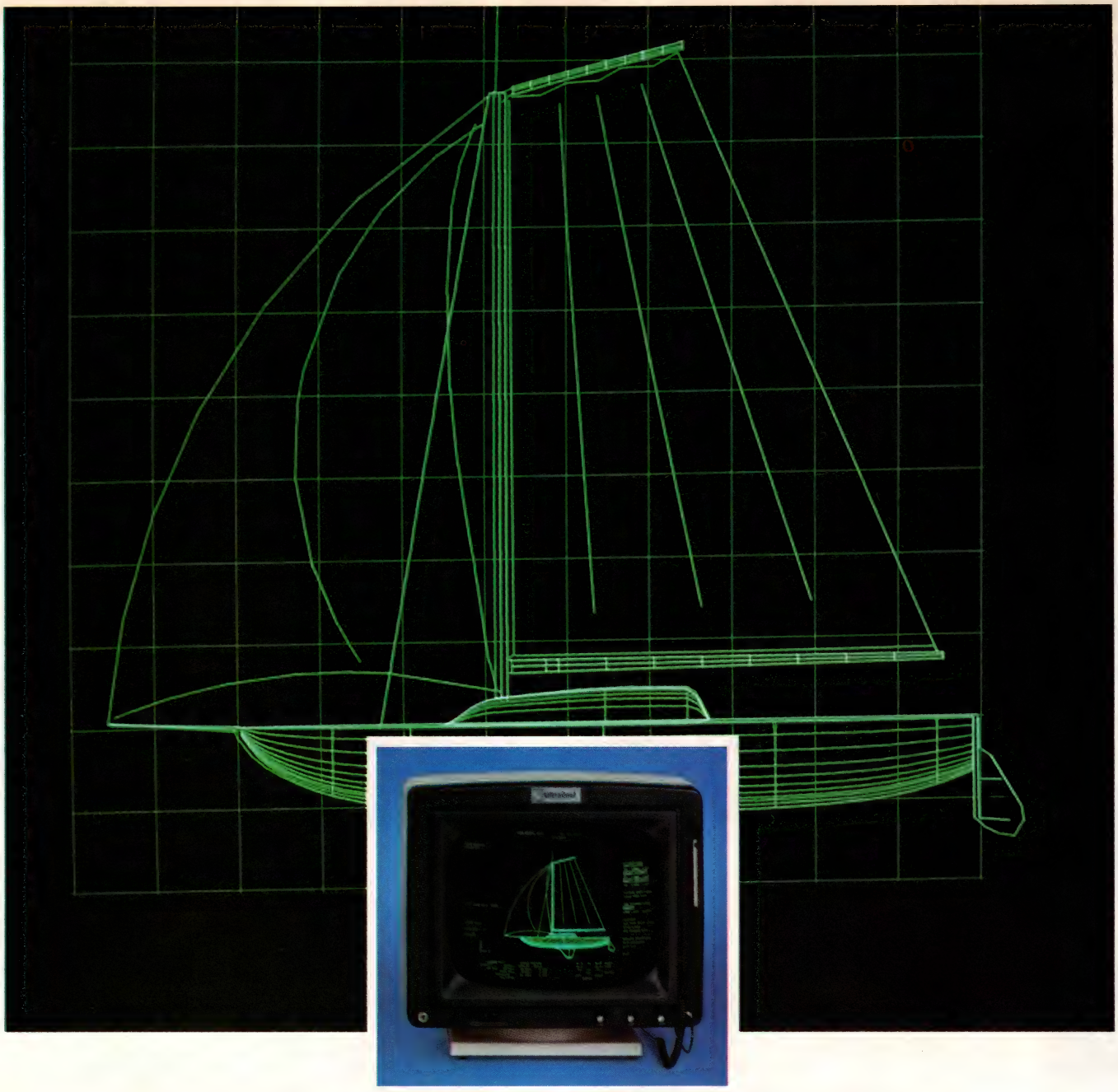
CIRCLE NO 79



Designing Is a Breeze with Lundy's New UltraGraf® II

No matter what business you're in, sluggish productivity could blow you—and your profits—away. But now, thanks to Lundy's new UltraGraf® II, there's an economical way to fight back. UltraGraf® II is an intelligent 3-D graphics workstation with features and functions that help you breeze through intricate designs.

Exceptional Quality and Performance

What sets UltraGraf® II apart from other workstations in its price range is its exceptional quality and performance. That's because Lundy engineers have developed extremely efficient vector and hardware processors that permit fast, high resolution design. And unlike many other workstations, UltraGraf® II is highly intelligent. So functions such as 3-D translation, rotation, and scaling are performed locally, increasing design speed even further while freeing your host. The result is fast, high quality design that helps keep rigid development schedules firmly on course.

A wide variety of options and accessories are available to help make graphics design as convenient as possible. And as with all Lundy products, UltraGraf® II is backed by our customer service and support network, one of the largest in the industry.

This combination of speed, intelligence, responsiveness, economy, options, accessories, service and support make UltraGraf® II the ideal choice for mechanical design and drafting, architectural engineering, finite element analysis, robotics, and other applications that require high resolution display.

So don't let sluggish design productivity take the wind out of your sails. Fight back with UltraGraf® II.

Contact: Graphics Marketing,
Lundy Electronics & Systems, Inc.
1 Robert Lane, Glen Head, N.Y. 11545
(516) 671-9000.

LUNDY®

CIRCLE NO 51

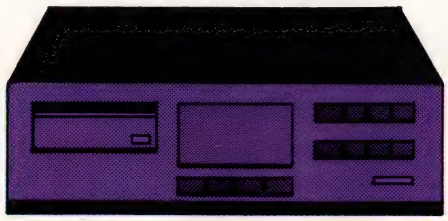
Select your favorite ads in this issue of EDN!

Reader Vote CONTEST

Enter the EDN Reader Vote Advertising Contest by following the three steps listed below.

1. Select the 10 ads in the August 7 issue of EDN that you think your fellow readers will choose as being the most helpful, informative, and attractive.
2. List your selections on the entry card provided.
3. Mail by September 18, 1986.

★ Top 3 prizes ★



Compact Disc Players

★ 10 ★

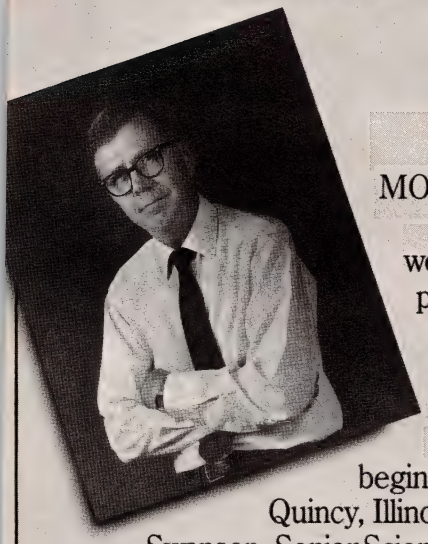
$25.00 Gift Certificates from Radio Shack

Contest Rules

1. List your top selections on the entry card provided. Be sure to indicate the name of the advertiser (company or organization) and the Information Retrieval Service or Reader Vote number for each advertisement selected. Do NOT use page number. (Ads placed by Cahners Publishing Company, EDN or other Cahners' publications cannot be considered in this contest.)
2. No more than one entry may be submitted by any one individual. Entry blank must be filled in completely, or it will not be considered.
3. To qualify, you must be engaged in electronic design engineering, supervising or managing design engineering, or setting standards for design components and materials.
4. Contest void where prohibited or taxed by law. Liability for any taxes on prizes is the sole responsibility of the winners.
5. Entries that most closely match the rank will be declared winners.
6. Entry cards must be postmarked before September 18, 1986.
7. In case of a tie, the earlier postmark will determine the winner. Decisions of the contest judges will be final.
8. In the event that a prize is not available, publisher may substitute an alternative prize of equal value without prior notice.

Anything's possible with Great Engineering.

One stormy night, lightning drove a spike into Hilmer Swanson's transmitter.



The GE Rugged MOSFETs survived.

Hilmer Swanson would need no further proof. GE MOSFETs delivered in the field what GE promised in its advertising.

But our story begins weeks earlier in Quincy, Illinois. Where Hilmer Swanson, Senior Scientist for Harris Broadcasting, was faced with the mystery of a Harris AM transmitter. It had suddenly stopped transmitting at a Texas radio station.

The transmitter was a Harris high power, solid state model. The units were the industry's first to advance from bipolar transistor technology to power MOSFETs. Consequently, they were smaller, used less power and, as a rule, were far more reliable.

Swanson traced the Texas transmitter failure to the non-GE MOSFETs. Despite reams of life-test data from their manufacturer, they were still failing under severe avalanche energy conditions.

Swanson suspected that the AM antenna that towered above the station was acting as a lightning rod, hurling destructive voltage spikes into the transmitter circuitry.

In a GE Semiconductor ad for a new series of Rugged MOSFETs, Swanson discovered a potential solution. While he began a series of tests in his laboratory, he also sent some GE Rugged MOSFETs to Texas for a real-world survival test.

Months in the field — and 1,800,000 device hours — have now gone by. And the GE Rugged MOSFETs have lived through everything the forces of Nature, and Hilmer Swanson, have thrown at them.

And, as you might expect, new Harris Broadcast transmitter designs feature the enhanced reliability of GE Rugged MOSFETs.

GE Semiconductor, alone among MOSFET suppliers, 100% tests all its GF series MOSFETs to specified energy ratings, publishes those ratings on spec sheets and stands foursquarely behind them.

We believe this is the only way to be sure GE Rugged MOSFETs, and the systems you put them in, will deliver the reliability that a good reputation depends on.

As Hilmer Swanson put it, "Our goal is zero failures. And the only real test of device specifications is whether the product works in real-world situations. We plugged GE's MOSFETs in, and they worked."

For complete information about GE Rugged MOSFETs, call us, toll free at

1-800-4GE-SEMI, ext. 701.

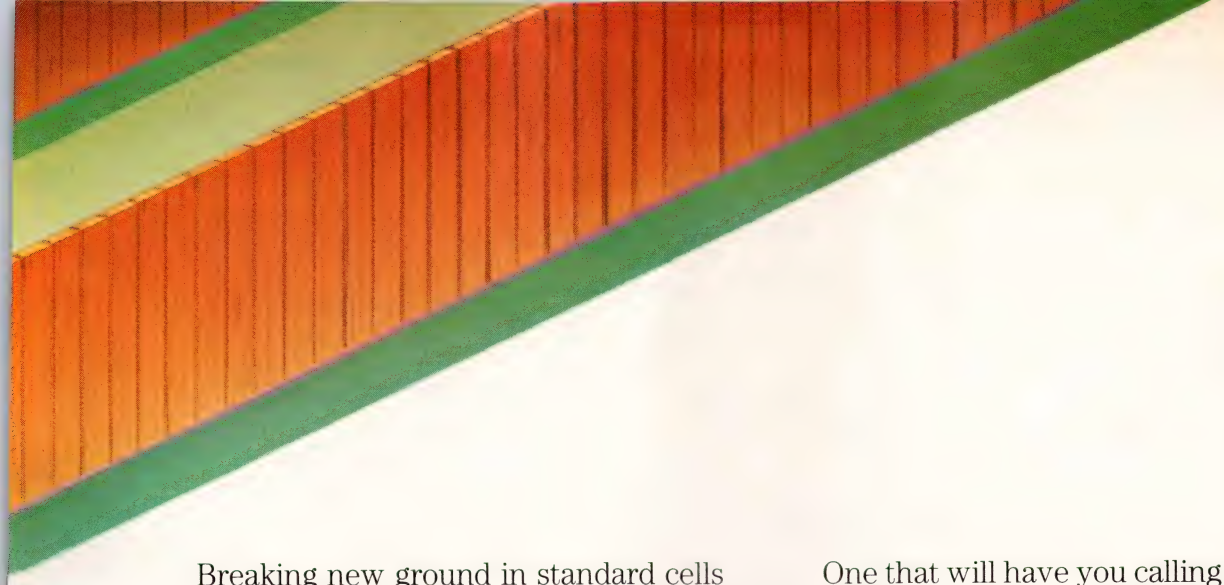
(In New York State, 1-800-2GE-SEMI, ext. 701.)

And next time a tough, real-world problem strikes, remember "anything's possible with Great Engineering." And call GE Semiconductor.

GE Semiconductor

CIRCLE NO 157

ZYMOS HAS ALWAYS BEEN A BIT OF A GATE CRASHER.



Breaking new ground in standard cells is nothing new at ZyMOS. Because we've been pioneering standard cell innovations longer than anyone. With hard-and-fast product. Not lofty promises about "soon-to-comes" and "wait-and-sees."

Now with our 1.8-micron CMOS standard cell library, we've taken the next logical step. Structured Block Silicon™ (SBS™). Our Super Cells (microprocessors, RAMs, ROMs and PLAs)—can be integrated to reach an unheard of 25,000-gate complexity. Reduce parts cost. Save board space. Improve system reliability.

SBS cells. Fabricated with our new Double-Level-Metal CMOS process, meet or exceed all of the timing requirements of the original devices. So you can create higher performance systems. With complete design freedom in aspect ratio, height and placement.

Find out more about our 1.8-micron standard cell library. And our SBS Super Cells. Contact one of our local sales offices and request a quote. We'll have a price for you within a week. One that will have you calling us back within days.

ZyMOS. Because when you put on a leading edge performance, it's a lot easier to pack them in.

SBS Super Cell Peripherals *

Z29C01	4-Bit Slice Microprocessor
Z29C116	16-Bit Slice Microprocessor
Z6818	Real Time Clock
Z74LS612	Memory Mapper
Z74S557	8 X 8 Multiplier
Z8237	DMA Controller
Z8254	Programmable Interval Timer
8255A	Programmable Peripheral Interface
Z8259	Programmable Interrupt Controller
Z8284A	Clock Generator
Z82284	Clock Generator and Ready Interface
Z82228	Bus Controller
Z8288	Bus Controller

* RAM, ROM and PLA Super Cells are also available using the ZyMOS ZyMEM silicon compiler.

ZyMOS Corporation
477 North Mathilda Avenue
Sunnyvale, CA 94086
Phone: (408) 730-5400
TWX: 910-339-9530 ZyMOS SUVL

ZyMOS
PRODUCING THE STANDARD IN CUSTOM VLSI

CIRCLE NO 103

Digital and Tektronix invite you to discover how powerful CAE can be.

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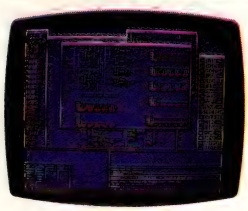

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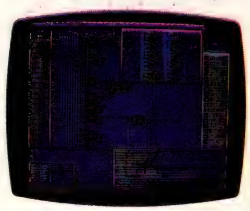

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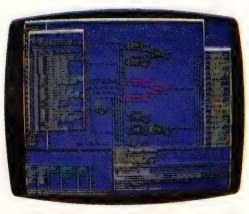

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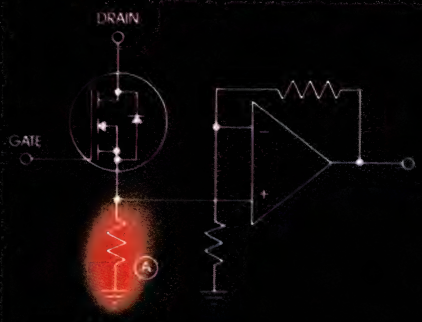

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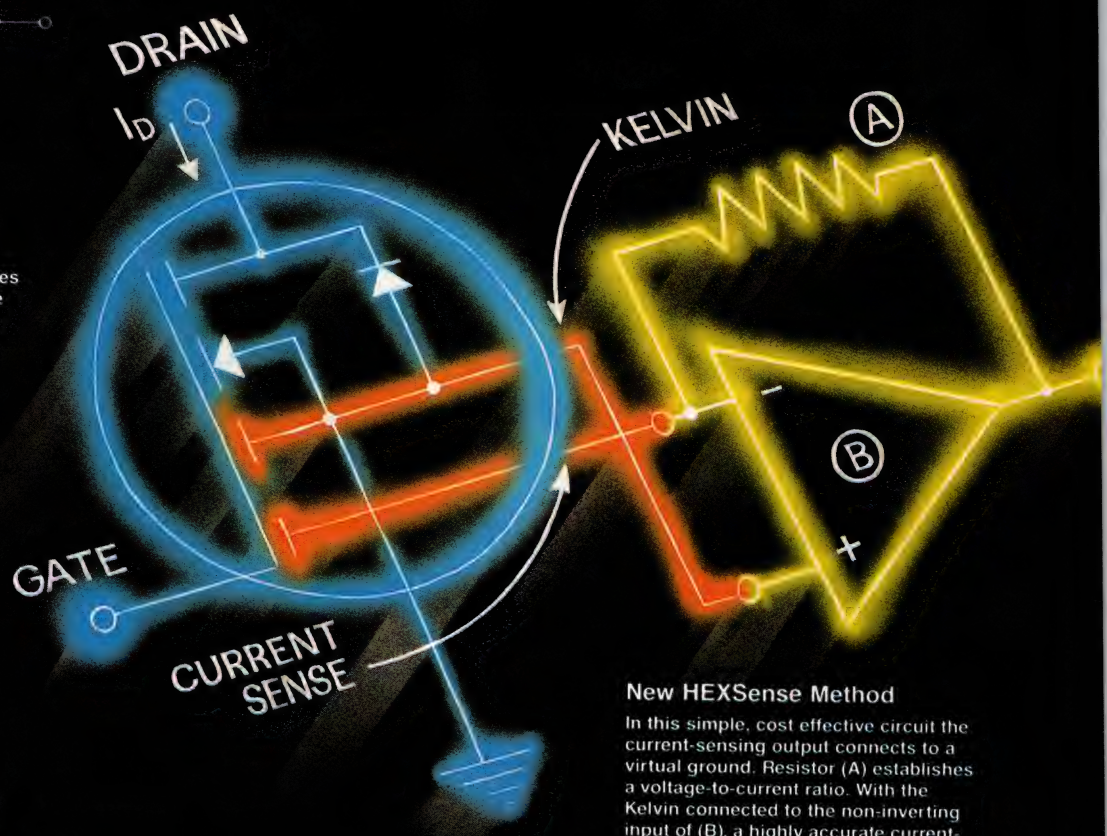

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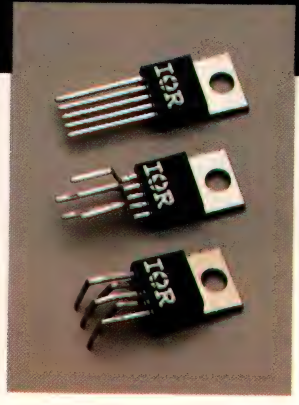

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Autorouters use sophisticated algorithms to lay out complex, multilayer pc boards

Eva Freeman, *Associate Editor*

When you're considering an autorouter for pc-board layout, be sure to take into account the autorouter's routing technique: Autorouters employ rip-and-reroute, maze, gridless, look-ahead, hugging, bus, and strategy algorithms, and even combinations of these algorithms. The different algorithms can produce very different results, so the kind of autorouter that will suit your purposes depends largely on the type of design you'll be laying out.

For instance, if your design is a complex one, you'll probably use a 100% router such as Cadnetix's CDX-75000, which uses a rip-and-reroute (or rip-up) algorithm to complete every interconnection on a board. If your design is simple, you won't need to use a 100% router; you'll find it easy enough to finish the layout manually. In that case, you can use a maze router like Telesis's EDA-620, which doesn't always complete every design, but requires far less time to route a board than does a 100% router.

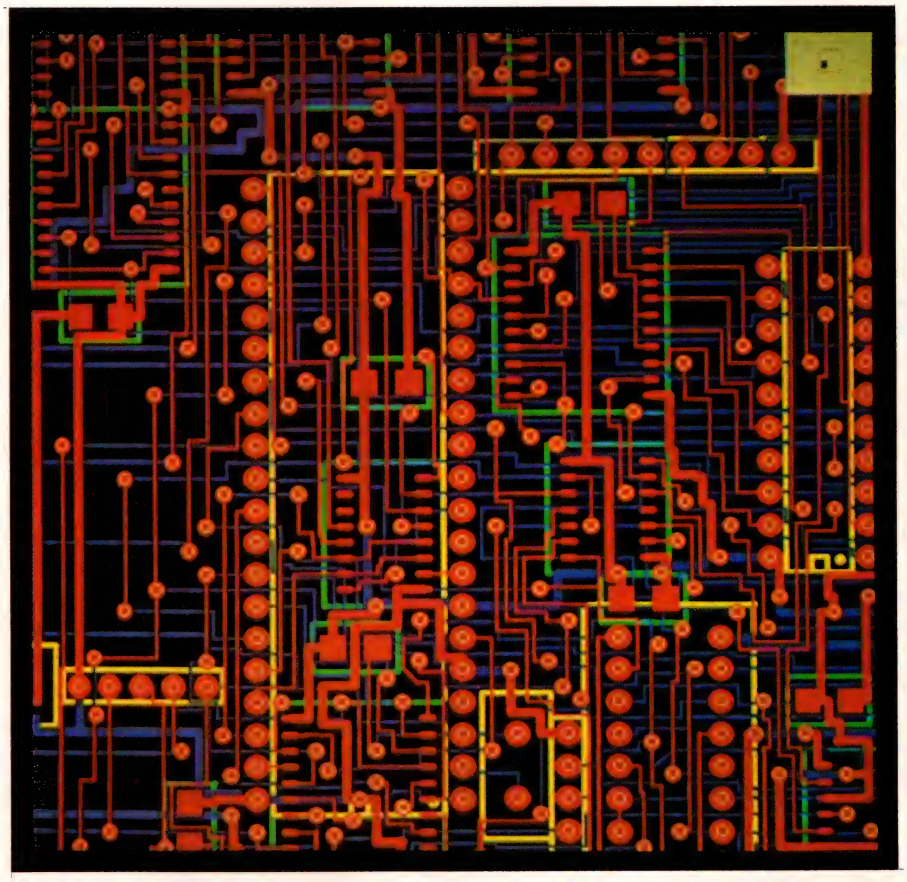

Fig 1—Autorouters can handle virtually every pc-board technology—*even multiple-technology designs, such as this representation (produced by Racal-Redac's Visula) of a 4-layer board that uses SMDs on one side and leaded components on the other side.*

Autorouters can be implemented in both hardware and software. The autorouters discussed here, which run for the most part on 32-bit workstations, can lay out multilayer boards and designs that include SMDs. Ports of these autorouters to personal computers, however, can't always handle multilayer boards because of the PCs' limited processing power (see **box**, "Low-cost autorouters run on personal computers"). You supply the autorouter with the component placement, and it produces a complete layout that you can use to generate photoplots and N/C drilling tapes. **Fig 1** shows the type of output that you can expect an autorouter to produce.

Rip-and-reroute algorithms

Although autorouters can run without operator intervention, not all autorouters complete every pc-board layout. Only autorouters that implement a rip-and-reroute algorithm can route 100% of every design. Rip-and-reroute autorouters continually evaluate their work; they remove traces that block routing paths, and they put those traces in areas where space is available (**Ref 1**). Rip-and-reroute systems always complete pc boards successfully, but they may require several days to complete a single design.

Furthermore, in completing every design, these 100% autorouters may insert a sizable number of vias in the boards. Such boards may therefore require more care in the manufacturing process. However, you can always reduce the autorouter's via usage by changing the operating parameters you supply to the machine.

To minimize the time that their autorouters require to complete pc-board layouts, Cadnetix and Calay

include custom hardware in their rip-and-reroute systems. Cadnetix uses both a 68020 μP and a bit-slice μP in its CDX-75000 Route Engine-Plus; Calay's autorouter includes the company's RPR246 custom hardware processor.

Calay offers its autorouter in both the company's $179,980 V04 CAD system and in its $24,000 RPR-300 off-line router. The off-line router lets you continue to use your CAD system while the router completes a layout, which may take several days. The off-line router interfaces to the company's V04, as well as to pc-board layout systems from Racal-Redac and Applicon.

The $77,000 CDX-75000 uses a multilayer routing technique. Unlike most autorouters, which evaluate multilayer boards two layers at a time, the CDX-75000 evaluates all layers of a pc board simultaneously. According to the vendor, the multilayer technique typically cuts both routing times and usage of vias in half.

Excessive via usage is probably the greatest drawback of the rip-and-reroute algorithm. Rip-and-reroute autorouters generally insert vias at almost every empty point on a routing grid and then remove unused or redundant vias. Although rip-and-reroute packages review via usage and remove as many vias as possible, they tend to use more vias than do other autorouters.

Maze autorouters

An alternative to the rip-and-reroute autorouter is the maze autorouter, which conserves via usage (thus improving pc-board yield) yet still maintains high completion rates. The maze router starts at the source of a signal and proceeds to its destination by wending its way across a layout, almost as a rat traverses a laboratory maze.

Both Telesis's CAD workstations and its EDA-620 stand-alone autorouter use the maze-routing tech-

Low-cost autorouters run on personal computers

If you want an autorouter, but don't want to spend tens of thousands of dollars on an autorouter that runs on an expensive 32-bit workstation, you have an alternative: You can generate your pc-board layouts on a low-cost IBM PC-based system. As you'd expect, autorouters that run on personal computers generally cost much less than packages that run on more powerful workstations. For example, although Case Technology and Academi Systems sell the same autorouter, the Maton autorouter from EIS (Geneva, Switzerland), Case's pc-board layout package, which runs on IBM PCs and compatibles, costs less than half as much as Academi's, which runs on a workstation based on DEC's MicroPDP-11. Case's automatic-layout package costs $9750 (the CT2500 autorouter is available separately for $5500); Academi lists its Solution 4000 layout package for $27,500.

The CT2500 (and Solution 4000) autorouter uses a succession of six passes in its routing procedure. In its first two passes, the autorouting program routes interconnections through horizontal and vertical channels; it inserts no vias. The four remaining passes use a maze algorithm; these routing passes insert successively greater numbers of vias (for example, one, two, four, and six vias) for each board trace. Because this autorouter adds vias only to those traces that were incomplete after the via-free passes were finished, the package keeps via usage to a minimum, thus producing a manufacturable pc board. The maze router further minimizes its use of vias by increasing the effective routing area. In other words, the algorithm completes difficult routes by allowing for longer traces instead of adding vias.

Software ports offer debugged algorithms

By incorporating a third-party autorouter such as Maton into a PC-based CAE package, a CAE vendor can offer a low-cost system that's also reliable—these existing packages have already been debugged and used successfully for several years. One company, FutureNet, derives not only its autorouter but its entire pc-board layout package from a third-party package developed by Vectron (Santa Clara, CA).

Dash PCB, FutureNet's pc-board layout package, uses a 2-step routing process. In the first stage, the autorouter examines a 1-in.-wide swath of a board and completes all routes that require no vias. In the second stage, a maze router completes most of the remaining routes within the 1-in.-wide swath. The program, which includes back annotation and CAM software, costs $13,000.

Many other vendors of PC-based CAE/CAD also use third-party sources for their autorouters. Aptos's third-party autorouter, for example, costs $5000. The company doesn't reveal the source of its autorouter; however, the program uses the same sequence of bus, pattern, and maze routers that Royal Digital's workstation-based Automate package uses.

Not all PC-based layout packages incorporate third-party software, however; some use proprie-

nique. Although the maze router can't lay out 100% of every board, the vendor reports two benchmarks in which the program routed 100% of a digital-and-analog pc board having 125 equivalent ICs, and 99% of an ECL board having 1381 equivalent ICs. What's more, the routing engine achieved these completion figures in 1.24 and 23.75 hours, respectively.

Unlike Cadnetix's and Calay's autorouting engines, the $47,900 EDA-620 contains no custom hardware. The stand-alone file server is a modification of the Sun Microsystems (Mountain View, CA) Sun-3 workstation. Because the autorouter is implemented in software, the vendor can easily update the autorouter.

Another stand-alone router that runs on a 32-bit workstation is Omnicad's $60,000 Omniroute. The Omniroute autorouter box comprises maze-routing software and a 32-bit RISC system. You don't have to buy Omniroute as a stand-alone system, though. You can buy it as part of a pc-board layout system from Tektronix or Calma; these companies include software implementations of this router in their respective Merlyn-PCB and Board Designer pc-board layout packages.

Calma has recently introduced the Board Expeditor stand-alone autorouter, which also implements Omniroute. The company has enhanced Omniroute by adding the capability of bending (and narrowing) board traces and increasing trace width in areas where space is available. The $75,000 Board Expeditor runs on an Apollo workstation.

Connect the traces

Although, like all maze routers, Omniroute doesn't route 100% of every circuit, it features a proximity router. When the system fails to complete a trace, the proximity router draws as much of the interconnection as it can determine.

tary autorouters. The Redcad package from Racal-Redac, for example, incorporates the vendor's own autorouter. This autorouter uses the same 3-part router as that in the Royal Digital and Aptos packages—a bus router for power supplies, a pattern router for memory areas, and a maze router for signal lines. The complete pc-board layout package costs $15,000.

The PC-Route package from Personal CAD also employs the company's own autorouter. The company recently quadrupled the speed of the PC-Route package by changing memory-address locations and overriding system-default routines. The $4500 package can handle designs containing as many as 6000 pins, 1000 nets, and 500 components.

Autodesk is now introducing an autorouter that interfaces to the company's drafting package. The autorouter is available in two versions: a $13,000 package that includes a 68008-based coprocessor board and an $18,000 package that includes a 68020 coprocessor. To complete a route, the autorouter uses two line-probe routing passes, two maze-routing passes, and two rip-and-reroute passes. According to the package's developer, the 68020-based coprocessor board enables this PC-based system to route boards faster than such workstation-based autorouters as the Calay package.

Inexpensive PC-based autorouters

If you're looking for a very inexpensive PC-based autorouter, consider the packages from Design Computation and Great Softwestern. For $2498, Design Computation's DC/Autorouter (which includes a 60-day money-back guarantee) implements a hugging algorithm that handles 16-layer boards as large as 32 in. on a side. Great Softwestern's $1495 Auto-Router 2.0 uses a rip-and-reroute approach to lay out 16×16-in^2 boards; two options ($500 each) add surface-mount and multilayer capabilities.

When you use Great Softwestern's autorouter, you can specify such parameters as pad-to-via, trace-to-trace, via-to-trace, and pad-to-trace clearances. The autorouter also features a via-minimization algorithm that removes unnecessary vias after the rip-and-reroute process is complete. The autorouter is part of the company's $2995 Auto-Board pc-board layout package, which operates only in conjunction with the AutoCad program from Autodesk.

Because it requires no add-on boards or additional software, Design Computation's $3597 pc-board layout package, which includes the DC/Autorouter program, is probably the least expensive layout program that offers automatic routing. The router uses a rectilinear hugging algorithm to route traces on each layer in either largely horizontal or largely vertical paths. If the hugging algorithm fails to complete a route, the program adds vias to the design. After the hugging process is complete, the program uses a rip-and-reroute algorithm to complete the board. According to the vendor, the autorouter's typical completion rates are 90 to 95%.

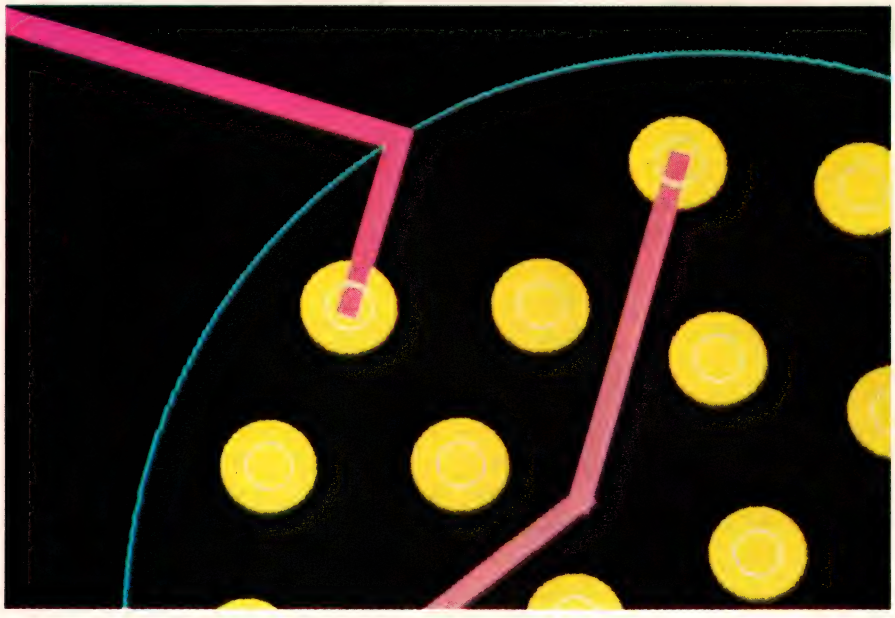

Fig 2—Gridless autorouters can easily perform *connections to off-grid pads, as does this gridless autorouter in Racal-Redac's Visula pc-board layout system.*

Completing the interconnection, of course, is up to you.

The Optimate pc-board layout system from Optima also employs the proximity-routing technique. Instead of focusing just on fully automatic routing, this router provides a semiautomatic mode that lets you route designs to an interactively selected point and then complete critical traces manually. Although this technique might appear to be slower than true autorouting, it can actually decrease your overall routing time by letting you intervene occasionally at critical points.

Optimate runs on Apollo Domain and DEC VAX computers. For use on the DEC MicroVAX II and Apollo DN560 and DN660 workstations, the package costs $40,000 to $55,000; the version that runs on the Apollo DN3000 costs $25,000. Optimate also appears in other companies' pc-board layout systems as a third-party product, as do many companies' autorouters. Both Valid and Silvar-Lisco include Optimate in their pc-board-layout systems.

Because a port of an established product is less likely to contain flaws than is a new program, the use of third-party autorouters in pc-board layout packages is widespread. Applicon uses a pc-board layout system from Algorex (Syosset, NY) in its Bravo3 CAD package. Algorex designs and manufactures pc boards; Bravo3's algorithms produce pc-board layouts that are both complete and manufacturable.

Other autorouters turn out complete and manufacturable pc-board layouts by employing hugging, gridless, or look-ahead algorithms. These techniques minimize via usage without creating excessively long or irregular traces.

A hugging router, unlike a rip-up router, makes room for traces by pushing existing traces and vias aside. Hugging routers must act in synergy with other routing strategies to produce manufacturable boards. In Royal Digital's Automate pc-board layout package, for instance, the hugging router operates in conjunction with a bus router and a strategy router. The bus router operates primarily on power and ground supplies; the strategy router specializes in circuits, such as memories, that feature repeated structures.

The bus router lays out only those nets that have direct source and target points. Because this router inserts no vias, you need to run it only once. The strategy router's ability to recognize patterns makes this algorithm ideal for memories. However, the strategy router can't handle random structures. Further, if you try to apply it to an entire board, it will produce a tangle of long traces and blocked paths.

Although bus, strategy, and hugging routers can't design a manufacturable pc board individually, the combination of the three algorithms in Automate produces manufacturable boards, yet requires less computer time than do other methods. What's more, Automate runs on the Data General DS 4200 workstation, on Prime computers, and on VAX and MicroVAX systems, and it's available in OEM quantities for IBM PCs. Automate costs $40,000 per user or $120,000 per site.

For the densest boards, a gridless router can be the best choice. These so-called gridless routers do in fact use grids, but the grids typically have 0.001-mil spacing. (In contrast, some gridded routers use 1-mil spacing, and some even have grid points spaced in multiples of 5 mils.) When they place traces, therefore, gridless routers are constrained only by the design rules that you impose; they don't have to conform to a large grid.

If you're considering using a gridless router, be sure to check your pc-board manufacturer's design rules first. If your manufacturer demands aligned conductors and large spacings between traces, for example, you may not be able to use a gridless router. On the other hand, to make a complex board (especially one that includes SMDs) meet critical speed specifications, you may have to use a gridless router; a gridded router might make the traces too long. In **Fig 2,** for example, you can form the connections to the off-grid pads only by using a gridless router.

Racal-Redac's Visula is a gridless router that uses the rip-and-reroute algorithm. Unlike other rip-up rout-

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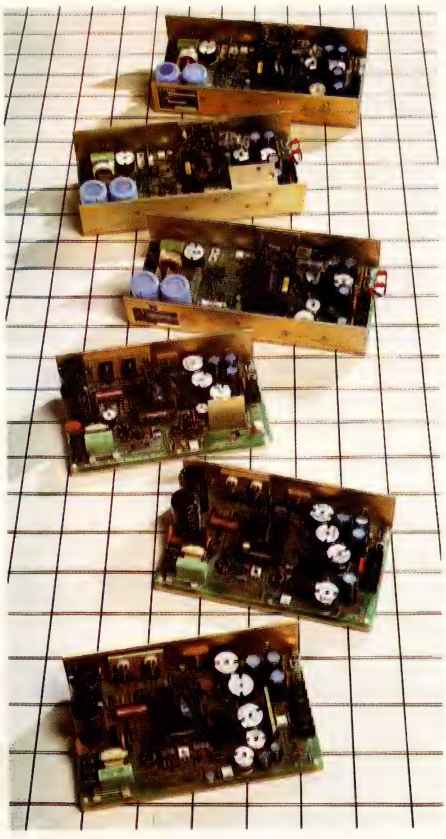

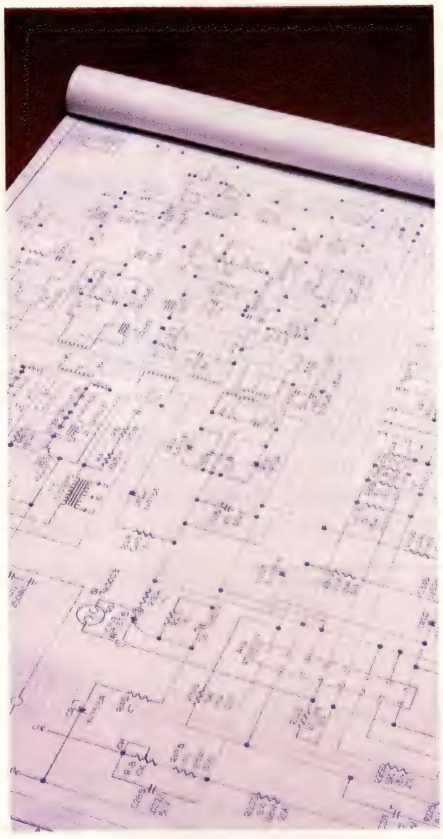

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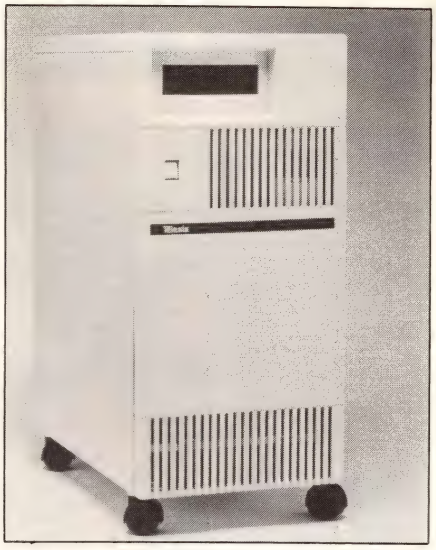

Besides freeing your CAD system for other design tasks, *a routing accelerator like Telesis's Sun-based EDA-620 decreases your routing time by a factor of five to 10.*

ers, which may remove large sections of a design when they detect a blocked path, this package tries to reroute traces by ripping up only a pair of routing paths at a time. Visula runs on all Apollo and DEC VAX computers. The least expensive version of the program runs on the Apollo DN3000; including the workstation, this package costs $70,000.

Mentor also uses the gridless approach in its $70,000 Board Station (which also includes an Apollo DN3000). The Board Station package relies on the maze-routing approach. Before you put this program into the automatic mode, you must assign relative values to such routing parameters as the insertion of vias, long interconnections, and bends.

Before you put Xerox's gridless router in the automatic mode, you can assess your routing scheme from a global perspective. The global router sketches connections between parts, not in a rat's nest, but in the actual routing channels. By revising your global route before you start automatic routing, you can keep long routing paths and via usage to a minimum. The company's $32,500 pc-board layout package runs on its $12,000 Model 6085 workstation.

Another type of autorouter—the look-ahead autorouter—plans layouts before laying down interconnections. These autorouters enable

For more information . . .

For more information on the pc-board autorouters described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Academi Systems Inc
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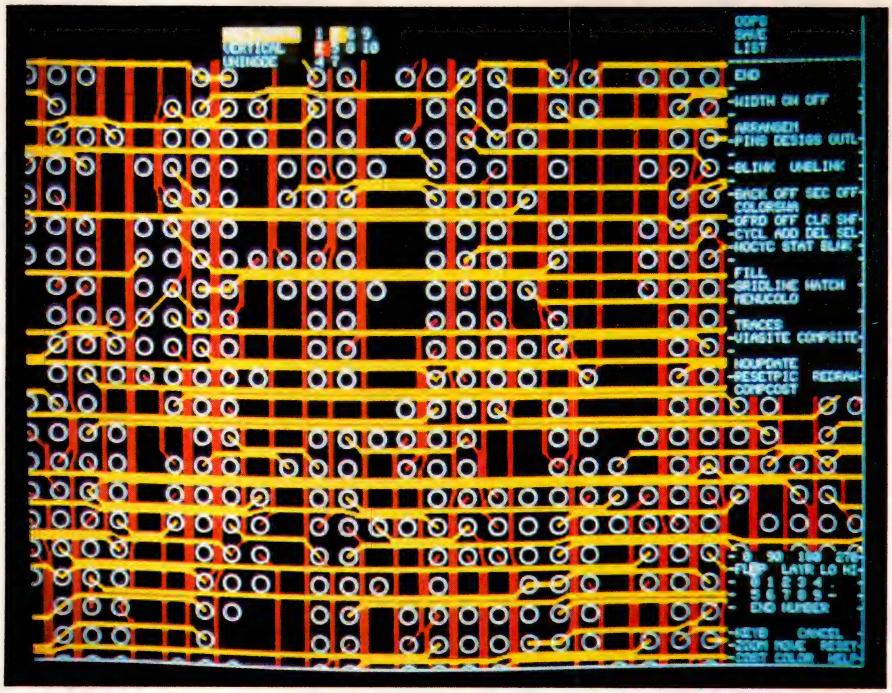

Fig 3—A look-ahead router, *such as Scientific Calculations' Look Out, plans a multilayer design completely before it starts to solve the interconnection problem.*

you to create complex layouts like the one in **Fig 3.** Hewlett-Packard and Scientific Calculations each offer pc-board autorouting packages that incorporate look-ahead algorithms.

Scientific Calculations' Look Out router features a gridless, look-ahead algorithm. According to the vendor, the autorouter took just over 10 minutes to complete a 6-layer 11×7.6-in^2 board that had 429 components, 1699 connections, and a 0.33 equivalent-IC density. The autorouter, which is an integral part of the company's $25,000 Sicards pc-board layout package, runs on the vendor's 68020-based workstations and on all VAX computers.

Hewlett-Packard's Printed Circuit Design System offers the choice of 20-, 25-, and 50-mil grids. You can evaluate the progress of the look-ahead router during a route. The pc-board layout system includes the company's 9000 Series 300 workstation; the system costs $60,000 to $82,000.

Autorouters are a bit like word processors—they can improve the appearance of your work, but they can't improve its quality. No matter which autorouter you choose, you must place components on your layout so that the routing problem is as simple as possible; otherwise, your autorouter will generate excessively long routes, insert many unnecessary vias, and possibly even require extra signal layers.

At present, most pc-board designers place all the components on your layout interactively; not many use automatic-placement software. CAD vendors are already offering automatic-placement programs, but such programs have not been as useful as autorouters for complex pc boards have. When automatic-placement software can design the complex boards that autorouters can lay out, fully automatic pc-board layout will become a routine procedure. **EDN**

Reference

1. *AutoTool Check List,* Aptos Systems Corp, Scotts Valley, CA, 1986.

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High 500 Medium 501 Low 502

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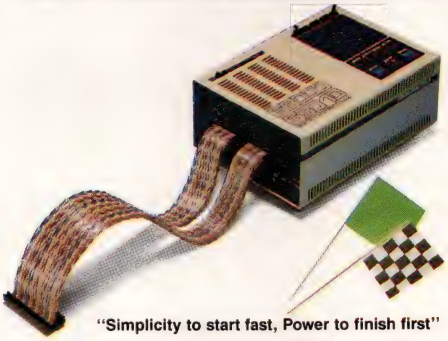

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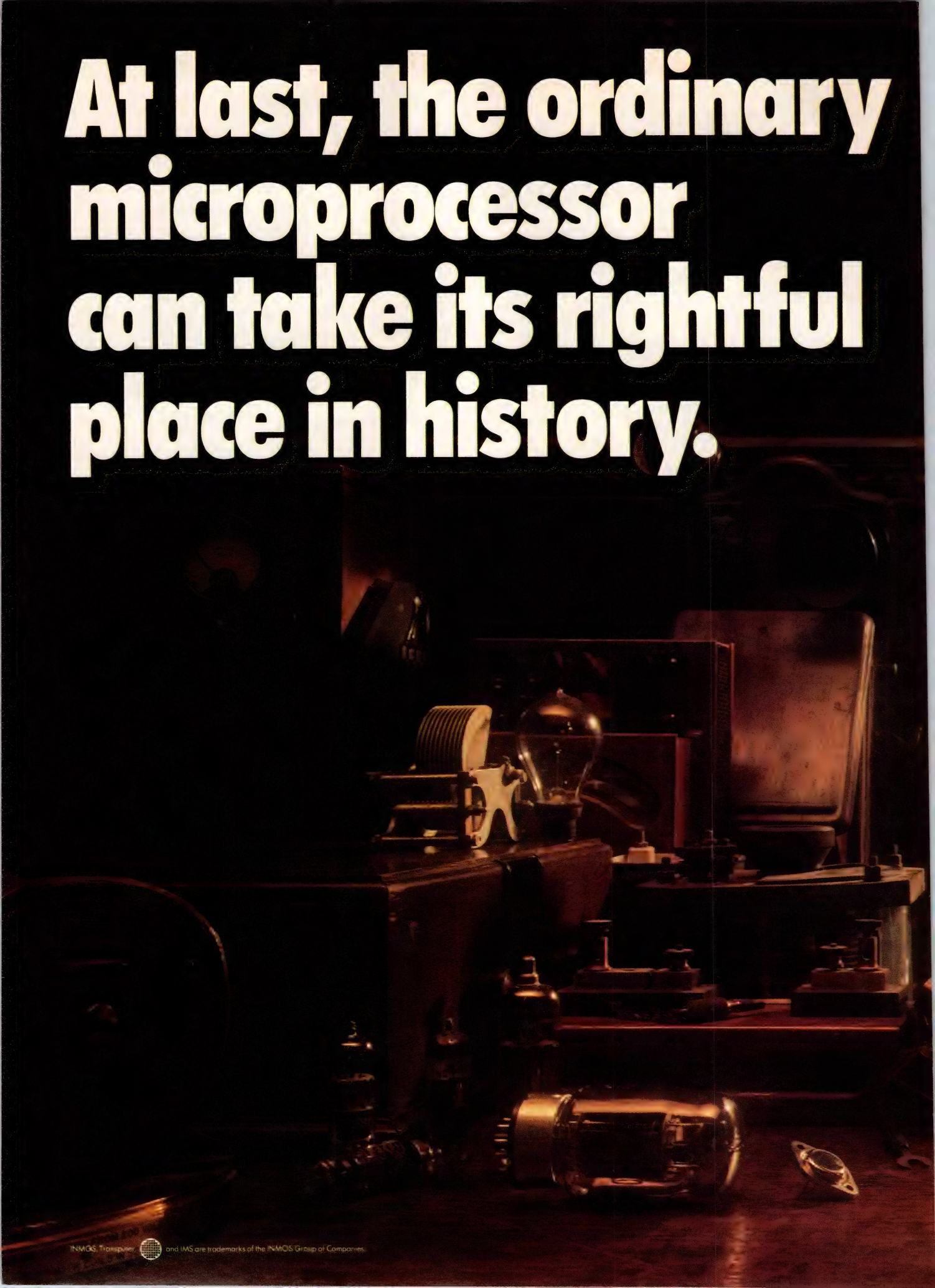
CIRCLE NO 61

At last, the ordinary microprocessor can take its rightful place in history.



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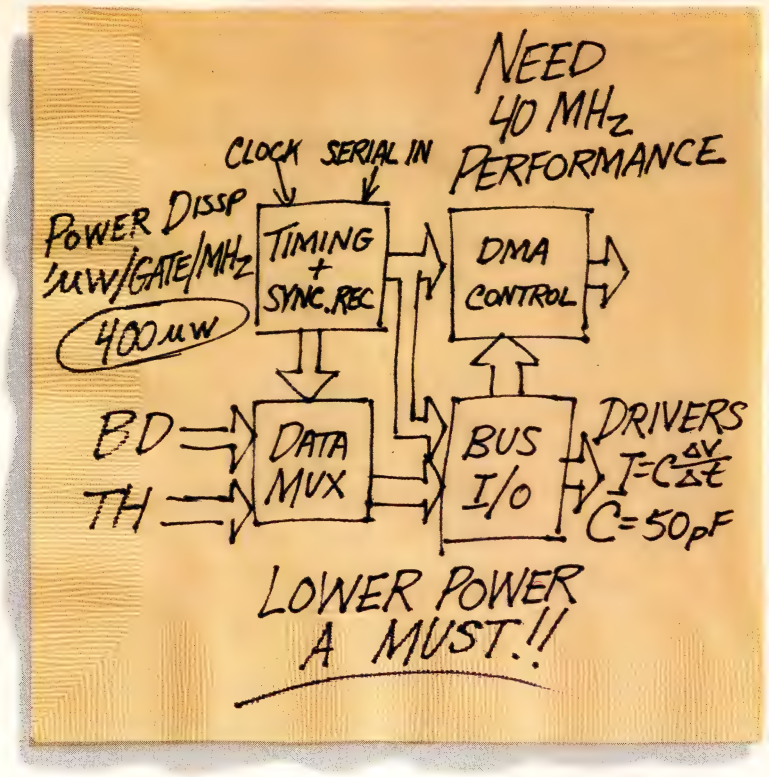

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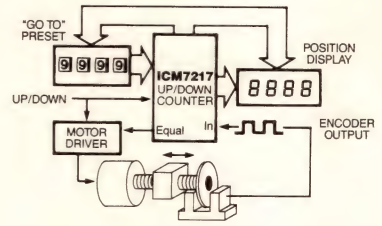

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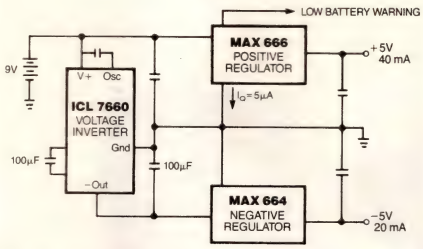

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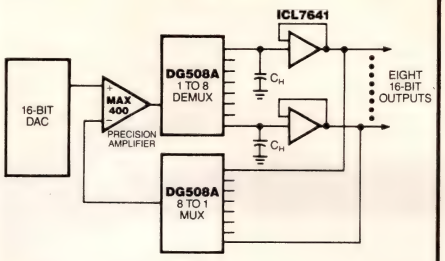

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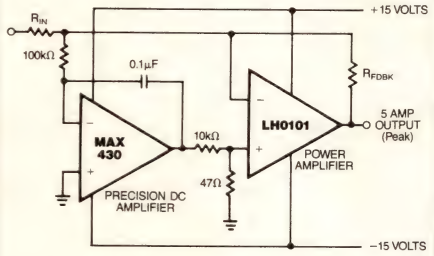

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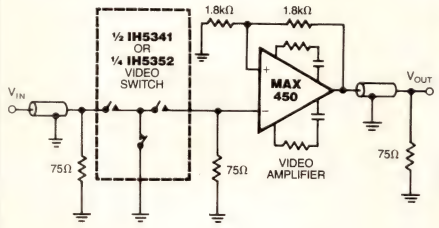

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CIRCLE NO 86

Intelligent modem ICs integrate functions, simplify design of communications circuitry

Maury Wright, *Regional Editor*

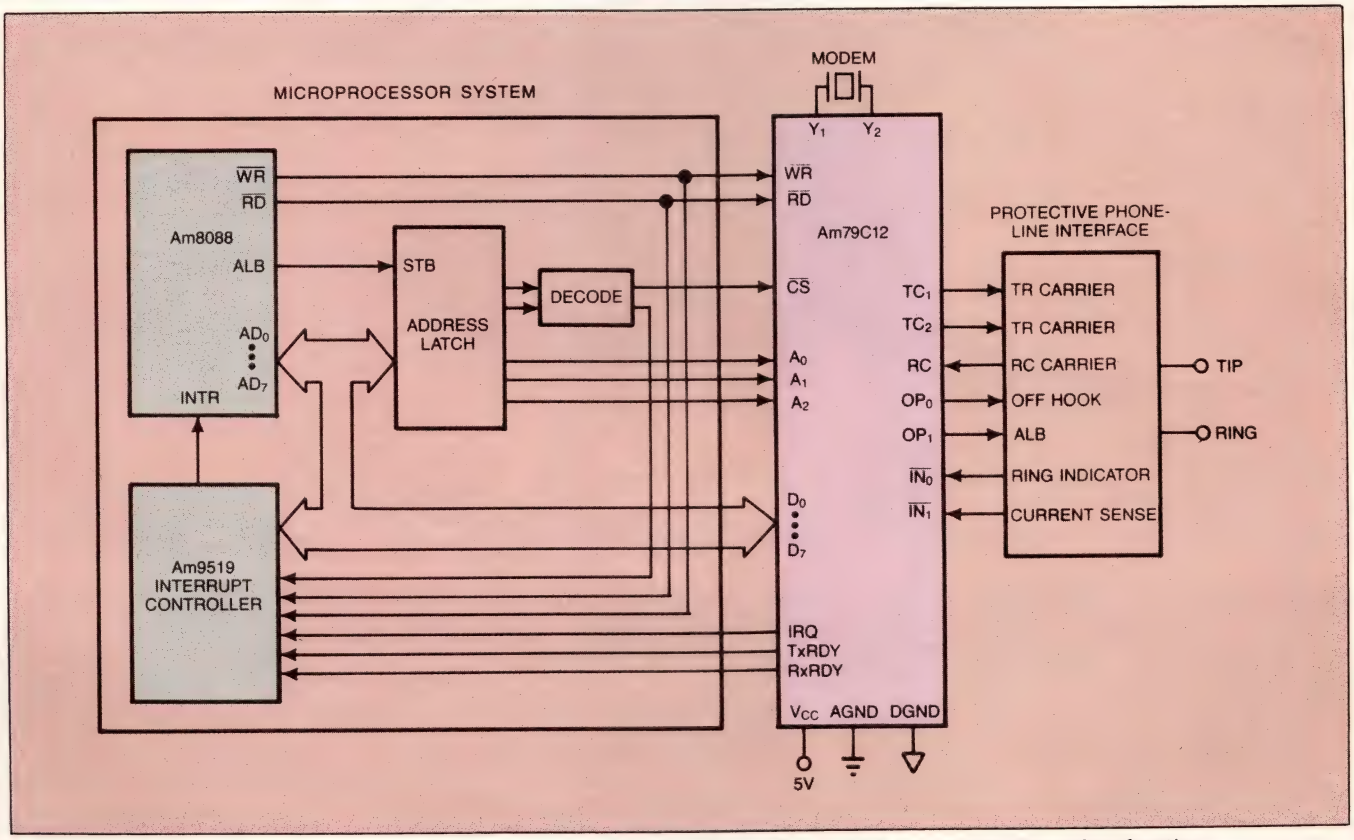
Using the latest generation of modem ICs, digital designers can embed 1200- and 2400-baud communication facilities within their products. The modem chips and chip sets interface to μPs in the same way disk-controller and other peripheral ICs do. Except for the data access arrangement (DAA)—the rather complex circuitry that serves as the interface to the phone line—the designer needs few components other than the modem chips to implement the modem function.

The ICs, and the accompanying support of the IC manufacturer, can help a designer with no prior modem design experience build an integral modem into portable terminals, computers, test and measurement equipment, and many other products. The combination of the hardware, hardware support, and software support will even allow the designer to create a modem with a Hayes command set (see **box,** "A standard command set for intelligent modems"). In addition, modem-IC manufacturers normally provide acceptable DAA designs.

Your application will be a key factor in choosing among the various modem-chip offerings. Factors that will influence your attempt to match a modem IC to your application include

- level of integration
- degree of flexibility
- interface (eg, parallel or serial)
- support (from design help to firmware)
- communication standards
- price
- power requirements
- performance (transmission quality).

The flexibility that modem ICs can confer typically varies inversely with the level of integration they achieve: The more functions integrated onto a chip, the less flexibility the designer will have. For example, if a given modem IC provides the ability to interface to a specific μP, you'd have to add circuitry to make that modem IC compatible with other μPs. Of course, higher



Connecting to a μP's local bus, *Advanced Micro Devices' Am79C12 only requires a DAA to complete the modem function.*

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CIRCLE NO 155

Created by Dayner/Hall, Inc., Winter Park, Florida

levels of integration typically result in simpler designs.

Modem chips or chip sets must include a certain number of features to be of use to the engineer who's inexperienced with modem design —ie, they must achieve a certain, minimum level of integration. First, the chips must include such standard modem functional blocks as the modulator/demodulator, a sync-to-async converter, an async-to-sync converter, a scrambler/descrambler, and loop-back capability. If you were to try to effect these functions using discrete components, you would need considerable design expertise.

A minimally intelligent autodial/autoanswer modem IC must have several other features as well. For example, the modem must include a dialing function for both pulse and tone (DTMF—dual tone multifrequency) dialing. The modem also requires circuitry for answering the phone and for detecting the progress of a call. Finally, modems require a highpass filter and a lowpass filter near the DAA interface. Most of the modem chips and chip sets described in this article achieve this minimal level of integration.

To distinguish their chips and chip sets from one another, manufacturers of intelligent modem ICs add other features. For example, the Am79C12 modem from Advanced Micro Devices includes, on chip, facilities for interfacing the chip directly to a μP's local bus—functions normally handled by a dedicated microcontroller. The 79C12 can perform handshaking, detect errors, and initiate call retries. Handshaking, including a "training" phase, occurs between the modem IC and the remote modem. The training phase allows an answering modem to adjust to the communication speed and protocol of the calling modem. By relieving a dedicated μP of these tasks, the 79C12 lends itself to applications that can put to better use the board real estate an extra μP would consume—to say nothing of the money saved.

UART required for interfacing

An on-chip UART also eases the task of interfacing the μP to the 79C12. The UART is required to convert serial data to parallel data and vice versa, and it provides registers that are useful for programming the modem chip. Of course, you can also use the 79C12 to build a stand-alone modem, which would require a dedicated μP.

A standard command set for intelligent modems

Manufacturers of modem ICs that communicate at 2400 baud and under have begun to offer the Hayes command set, just as box- and card-modem manufacturers have already done. The inclusion of the Hayes command set in firmware renders a modem IC compatible with μC applications, because the applications software packages that today's desktop computers use to drive the modem employ the Hayes command set. Furthermore, an intelligent modem IC needs some kind of command set, and it's easier for a designer to start with the Hayes set rather than from scratch.

The need for a common modem command set arose when modems for dial-up applications evolved from the simple acoustic coupler to the autodial/autoanswer direct-connect modem. Seemingly overnight the intelligent direct-connect modem became standard μC equipment. These modems, however, required intelligent software to interface with μCs, and lack of a specific effort to set standards left it up to the market to establish one command set as the leader.

Hayes Microcomputer Products (Atlanta, GA) was one of the first companies to enter the market for intelligent, 300- and 1200-baud modems, and it quickly garnered a large percentage of the market share. Because of Hayes's market presence, the Hayes command set became a de facto standard. Application software developers included Hayes-compatible drivers in their communication software. Most other manufacturers of μC modems now support the command set.

Command set available as source code

Modem-IC manufacturers offer Hayes commands in the form of mask-programmed ROMs for custom processors, or firmware for popular general-purpose μPs. In fact, the manufacturers will typically provide source code for a particular processor. The designer can use the source code as is or modify it.

Although the Hayes command set resides primarily in software or firmware, you do have one hardware concern when you're designing the modem IC into your product. The command set and much of the application software that employs it rely heavily on the architecture of the Intel 8250 UART. The register structure of the UART is instrumental in Hayes-compatible operation.

Modem cards for IBM PCs require the 8250 UART along with the modem IC. Stand-alone modems that connect to the computer via a serial link typically don't require a UART, because the UART already exists in the computer's serial interface. Modem-IC manufacturers, such as Sierra and AMD, incorporate an 8250-like UART in the modem chip or controller.

The 79C12 supports the Bell 103 and 212A communication standards (see **box,** "Meeting standards at home and abroad"). Production quantities of the 79C12 will be available in September, and AMD has set a $25 to $35 (1000) price range.

Sierra Semiconductor's SC11004 1200-baud modem chip includes all of the minimal functions for integration, and it adds a 2- to 4-wire interface to the DAA. Without the 2- to 4-wire interface on chip, you must add an external hybrid circuit. If the on-chip interface doesn't meet your needs, you may still add the external hybrid. The SC11004 supports Bell 103 and 212A and CCITT V.21 and V.22 standards.

Full IBM PC bus connection

Even more important, when you configure the modem chip with the company's SC11007 controller, you've got a straightforward interface to the IBM PC bus. The controller IC consists of a custom microcontroller with 128 bytes of RAM, 8k bytes of ROM, 74LS244-type buffers, and a UART whose architecture is equivalent to that of the Intel 8250 UART. The 8k-byte ROM includes all the firmware required to implement a Hayes-compatible modem for the IBM PC. In fact, the modem IC, controller IC, and DAA make up the entire modem card.

Sierra also offers the SC11008 controller for stand-alone modem applications, which features a serial interface rather than the interface to the IBM PC bus. Like the SC11007, the SC11008 includes the Hayes command set.

The SC11004 modem sells for $50, and the SC11007 and SC11008 controllers cost $20 each. (Prices are for 100-piece quantities.) The $52 SC11014 modem IC duplicates the features of the SC11004, but adds a proprietary V.22-to-V.21 fallback mode. You can also use the Sierra modem ICs with standard μPs rather than with the custom controllers. The modems interface with the μP via a serial, 4-bit I/O port.

The MP212A 2-chip modem from Micro Power Systems combines many of the functions found on both Sierra's SC11004 and AMD's 79C12. The MP212A includes handshaking, a 2- to 4-wire converter, and a UART. The chip set supports the 103, 212A, V.21, and V.22 communication standards.

Micro Power Systems offers the modem chip set in a version that connects to a μP's local bus and in a version that's intended for stand-alone applications. The chip set also features equalization that adjusts to normal and worst-case phone-line conditions. The set costs $35 (1000).

Silicon Systems has elected to preserve flexibility, rather than heighten the level of integration, in its SSI K212 family of modem ICs. Each member of the family includes all of the basic functions required in an intelligent integral modem. A parallel interface, compatible with most μPs, connects the modem IC to a dedicated microcontroller; the modem chip must receive serial signals from the host computer via a UART or a serial interface (RS-232C).

The basic SSI K212 modem costs

Meeting standards at home and abroad

Modem-IC manufacturers face the problem of designing chips that meet distinct domestic and international communication standards. Although few of today's modems mix communication schemes, in the future modems will offer universal compatibility, because designers will demand it. Equipment designers who integrate a modem into a product would prefer to use the same modem-IC design for all products rather than use completely different designs to meet different communication standards.

Domestically, AT&T established the Bell 212A and 103 standards for 1200- and 300-baud communications, respectively. The 212A standard specifies a fallback mode to 300 baud, which comes into play when transmission at a slower speed is required to overcome bad line conditions. In the worldwide arena, the International Telephone and Telegraph Consultative Committee (CCITT) sets communication standards.

The CCITT V.21 and V.22 standards govern 300- and 1200-baud communications, respectively. Unlike the 212A standard, the V.22 specification does not include a fallback mode to 300 baud, but to a 600-baud rate instead. Several modem and modem-IC manufacturers, however, have developed proprietary schemes for the V.22-to-V.21 fallback mode. The CCITT V.22 bis standard specifies both domestic and international communications at 2400 baud.

Manufacturers currently use two approaches to meet the need for modem ICs that conform to different communication schemes. In some cases, the manufacturer produces ICs that only vary in the standard supported. In other words, three separate ICs may have identical footprints and architectures, but they may support three different standards, such as 212A, V.22, and V.22 bis. However, some manufacturers have already managed to combine support for multiple standards on a single IC, and multistandard modem ICs should become the rule rather than the exception.

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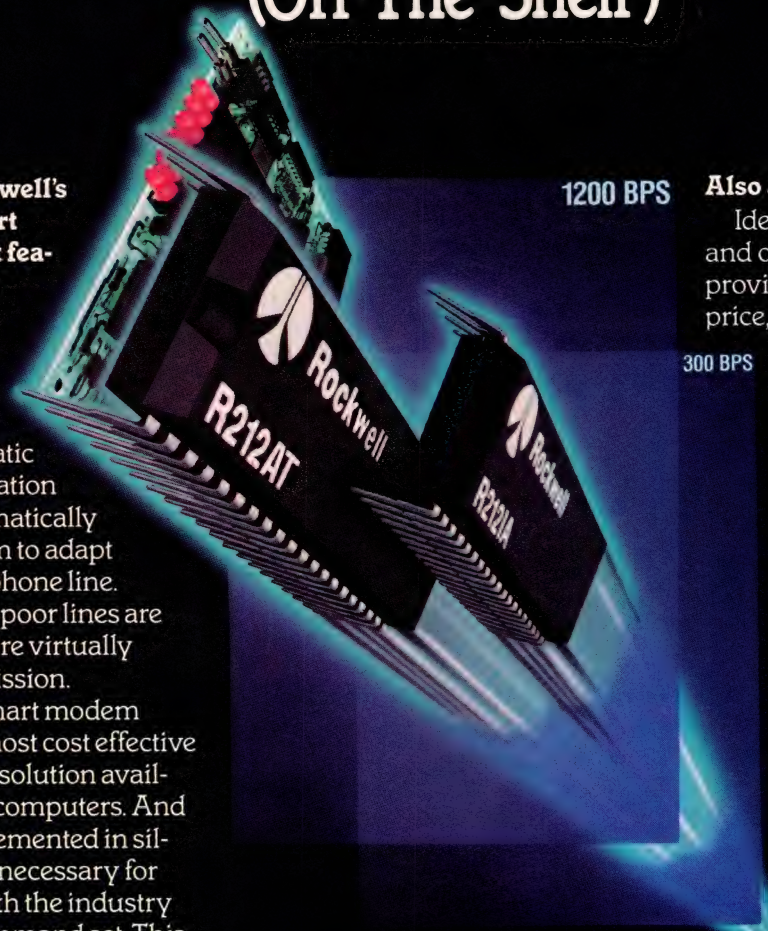

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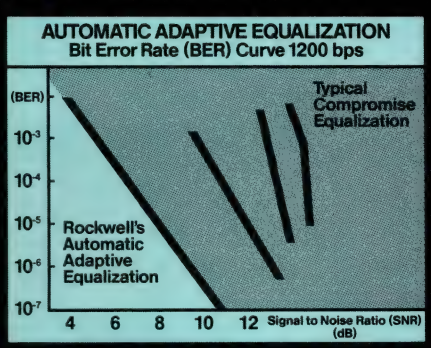
The R212AT smart modem offers lower system cost because it incorporates the controller and analog filter circuitry required for modem communications in the device set itself. This reduces parts count, enhances total system reliability and meets low power requirements for portable applications.

As well as operating asynchronously, the R212AT has synchronous mode operation for higher transmission throughput.



Also available: Rockwell's R212DP.

Ideal for remote diagnostics and other integral applications, it provides specific advantages in price, performance and system cost savings.

The R212DP, like the R212AT, has automatic fall back to slower speeds and an RS232C interface. Both these Bell 212A and 103 compatible device sets are available at any level of integration from devices to boards or customized private label systems.

For ease of evaluation, Rockwell provides a board level evaluation modem for laboratory analysis to assure the performance and quality of R212AT and R212DP.

Call your local Rockwell distributor today for off-the-shelf delivery of an evaluation board complete with a Designer's Guide Kit.

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$33.23 (1000) and supports Bell 103 and 212A standards. The SSI K221 supports the V.21 and V.22 standards and costs $35.95. The $36.55 SSI K222 modem IC supports both the domestic and international standards. Silicon Systems plans to extend the product family with the SSI K224 by year's end. The SSI K224 will support the 103, 212A, V.21, V.22, and V.22 bis standards.

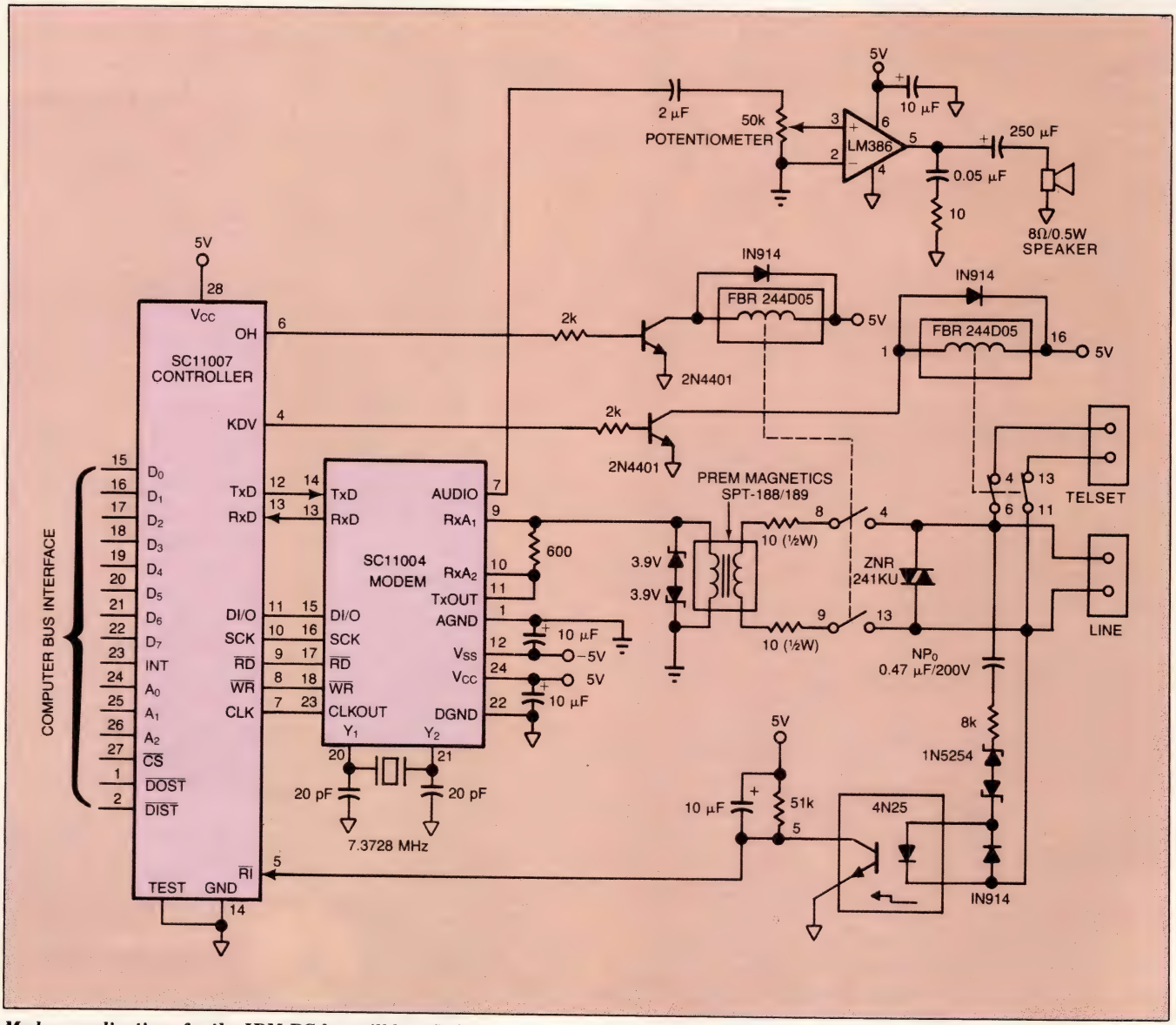
Silicon Systems' design approach allows you to choose the most cost-effective IC for a given application, yet use the same circuit design. Not only do the various chips fit in the same footprint on a pc board, but also all family members employ the same internal architecture. Silicon Systems uses the similar architecture to standardize firmware across the entire modem-IC family. By using the source code Silicon Systems offers, you can implement firmware, for a typical μP, that will work with the entire IC family.

Firmware support is common

All of the manufacturers discussed in this article provide some firmware support for implementing the Hayes command set. Most of the companies provide firmware for the Intel microcontroller family, and some provide firmware for other microcontrollers and general-purpose μPs.

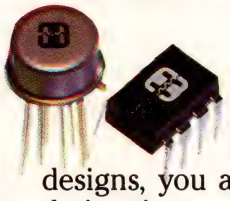
Designers should carefully evaluate firmware support if Hayes compatibility is important to the application. Modem IC vendors will provide a list of the supported commands, and you must be sure no commands you require are omitted. You are more likely to encounter such omissions when evaluating firmware for a 2400-baud modem than when checking 1200-baud modem firmware, because the 2400-baud command set is still evolving.

Modem-IC manufacturers also



Modem applications for the IBM PC bus *will benefit from the Sierra SC11004 modem IC and the SC11007 custom controller, which together provide the full IBM PC bus interface.*

Give your industrial controls a lift with our high-performance analog ICs.



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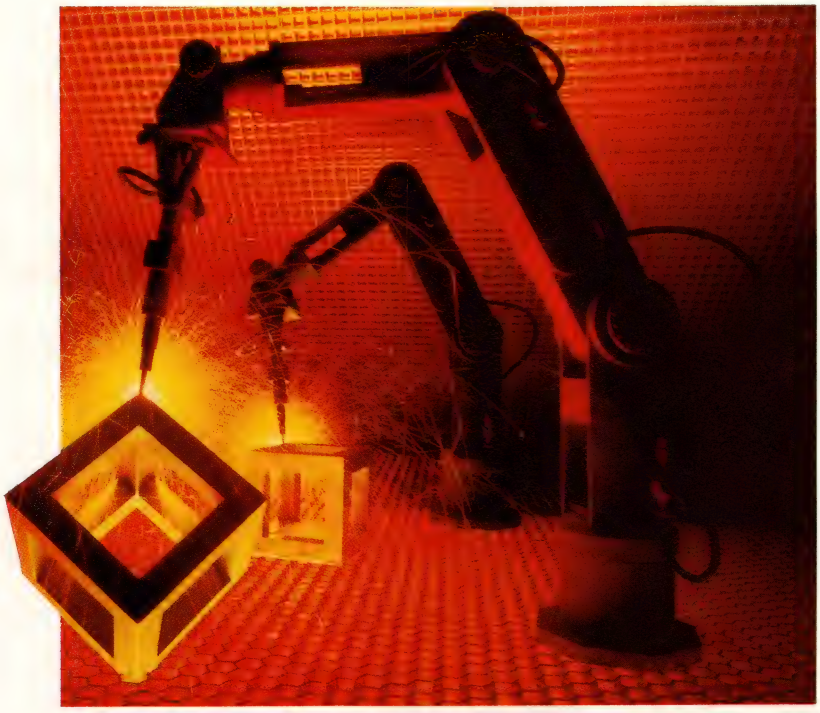

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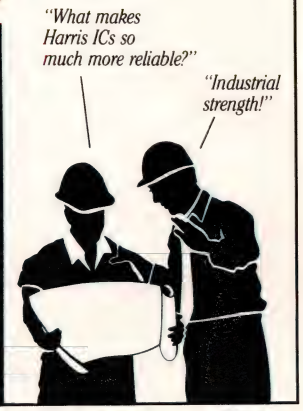


CIRCLE NO 77

offer substantial hardware support. The support comes in the form of designers' guides and evaluation boards, and designers are invited to virtually copy the evaluation boards to ensure working designs. All of the manufacturers discussed here offer some type of evaluation board.

DAA design is challenging

In particular, you'll need support when it comes time to build the DAA circuitry. The DAA isolates the modem from the phone line and therefore protects the phone line from power surges in the modem. Because no one offers a monolithic DAA IC, you must create the DAA from discrete components.

Modem-IC manufacturers take great pains to provide you with a suitable DAA design. Indeed, unless you have DAA experience, you should copy the board layout and schematic provided. The FCC must approve all DAA designs, so copying an approved design should ensure success.

Even if you copy a manufacturer's DAA design, you will probably still need to contract with a consultant to obtain FCC approval; a consultant can help you with the subtleties of the design and eliminate some of the trial-and-error process. Consultants typically charge $2500 to $3000 to go through the approval process with a design. You may also choose to buy a board-level DAA, but you will pay $75 to $100 for about $10 worth of parts.

The designers' guides from AMD, Rockwell Semiconductor, and Silicon Systems provide especially useful information. The guides give schematics, layouts, and parts lists for DAAs and modems. In addition, the guides attempt to explain the theory of operation behind the designs. Fairchild supplements its designers' guide with a Basic computer program that helps you design a DAA.

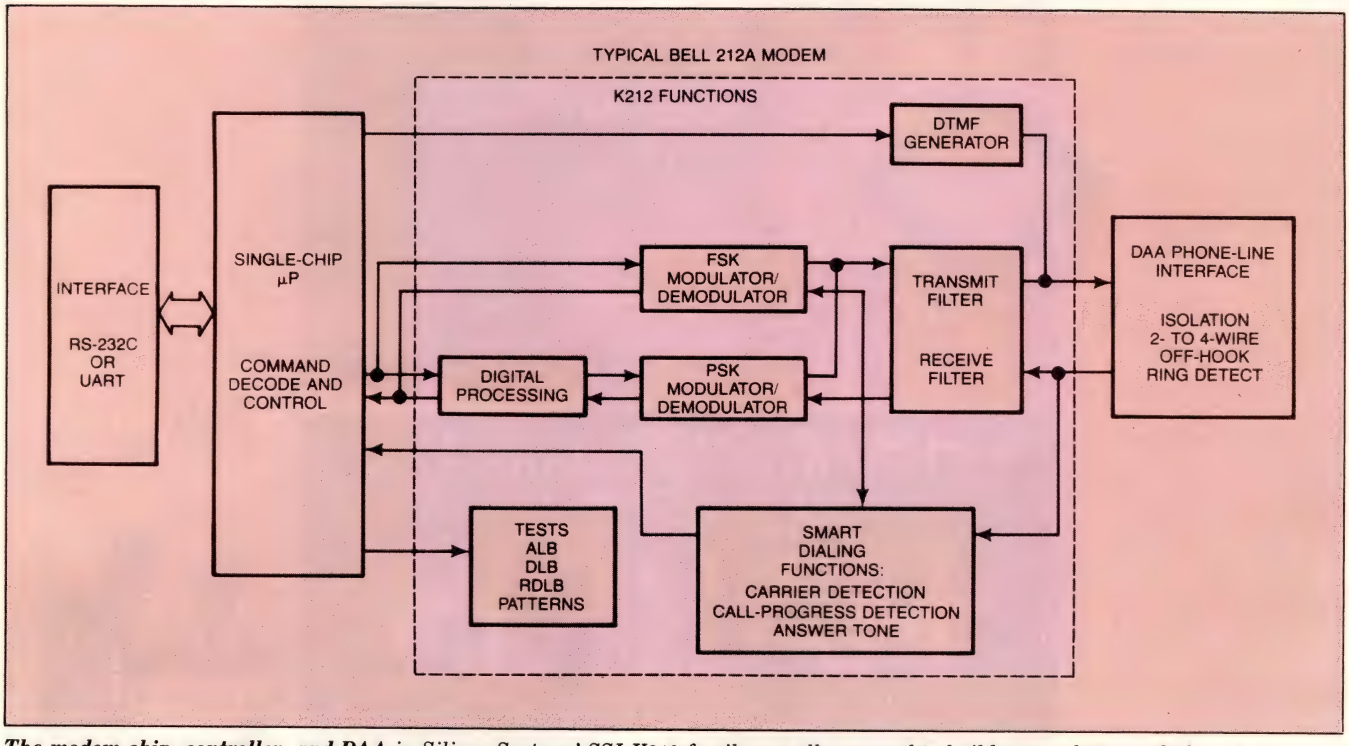
Ask about power consumption

One spec difficult to locate in designers' guides or data sheets is the power requirement for a given modem IC. If supply voltages or power consumption are critical to your application, you should specifically ask for this information.

For low-power applications, consider the μA212A or μA212AT from Fairchild. Although they require ±5V supply voltages, the ICs typically consume only 35 mW in an operating mode. The only difference between the μA212A and the μA212AT is the latter's inclusion of a DTMF generator and the former's requirement for an external dialing chip. The chips cost $20 and $25 (1000), respectively.

The Fairchild modem-IC family provides capabilities similar to those of Silicon Systems' parts, except that Fairchild's devices includes a 2- to 4-wire interface. The μA212A and μA212AT provide compatibility with Bell 103 and 212A communication standards. In the fourth quarter of this year, Fairchild plans to introduce the $25 (1000) μAV22 for V.21 and V.22 applications. Also in the fourth quarter, you can expect to see the $30 (1000) μA2212 for 103, 212A, V.21, and V.22 applications. The company's 2400-baud μA2400 is scheduled to appear in the first half of 1987.

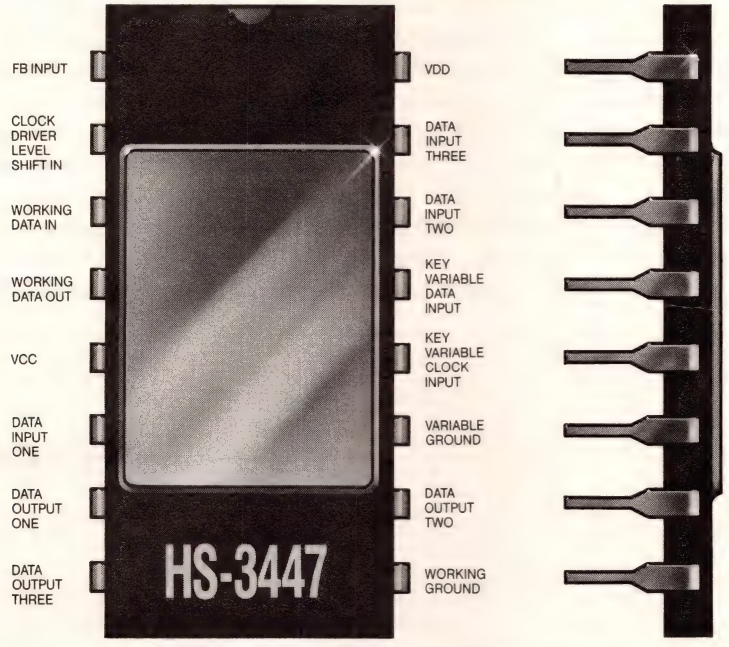
Sierra's SC11004 and Silicon Systems' SSI K222 are also stingy with



***The modem chip, controller, and DAA** in Silicon Systems' SSI K212 family are all you need to build a complete stand-alone modem.*

WANTED CYPHER-1™

Our NSA-endorsed encryption chip: more speed, less space than DES.



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power consumption. The SC11004 operates from a ±5V supply and consumes 100 mW. The SSI K222 chip operates from one 12V supply and consumes 150 mW when operating, but only 27 mW in standby mode. Other members of the SSI K212 family require only single 5V supplies. These parts, the $34.50 SSI K212L and $37.50 (1000) SSI K222L, provide functional compatibility with the SSI K212 and SSI K222. The low-power K222L consumes 40 mW when operating and 13 mW in standby.

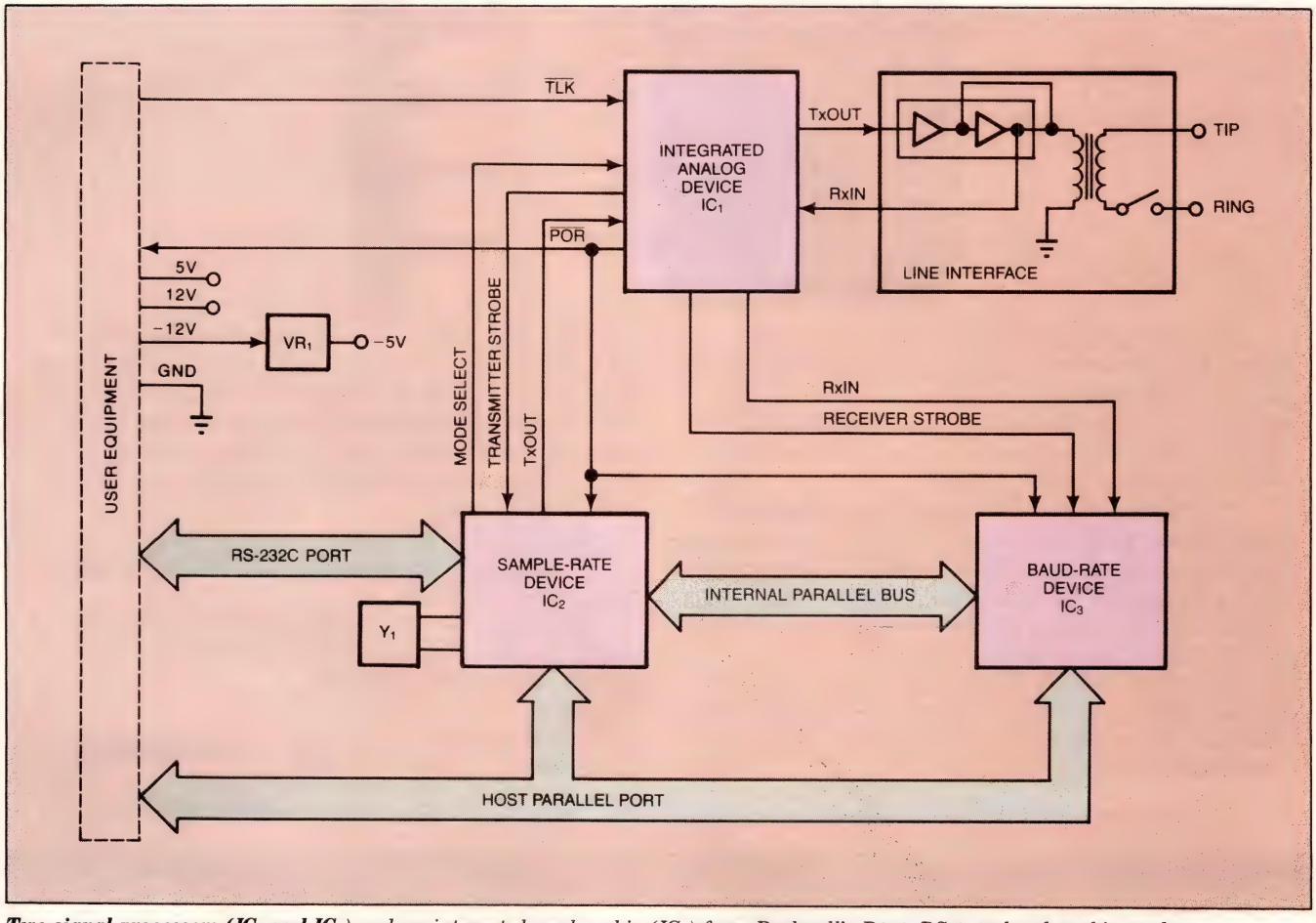
Another approach: DSP

These low-power ICs employ, for the most part, an analog implementation of the modem function—ie, they use passive components to effect the modulator/demodulator function. Companies like AMD and Rockwell are building modem ICs with less analog circuitry and more digital-signal-processing (DSP) circuitry; A/D and D/A converters and software simulation combine to perform the modulating and demodulating. Whatever efficiencies digitization may confer, you may pay a price in power: The AMD and Rockwell 1200-baud modems consume nearly 1W. Micro Power Systems' MP212A also uses DSP techniques, and it consumes 300 mW.

Rockwell offers the R212DP and R212AT modems for 1200-baud operation. The R212DP provides the basic modem functions, while the R212AT adds the Hayes command set in mask-programmed ROM. Both modems consist of a 2-chip set, and both come in versions compatible with 103 and 212A standards and with CCITT V.21 and V.22 standards. The R212DP costs $24, and the R212AT costs $28 (1000).

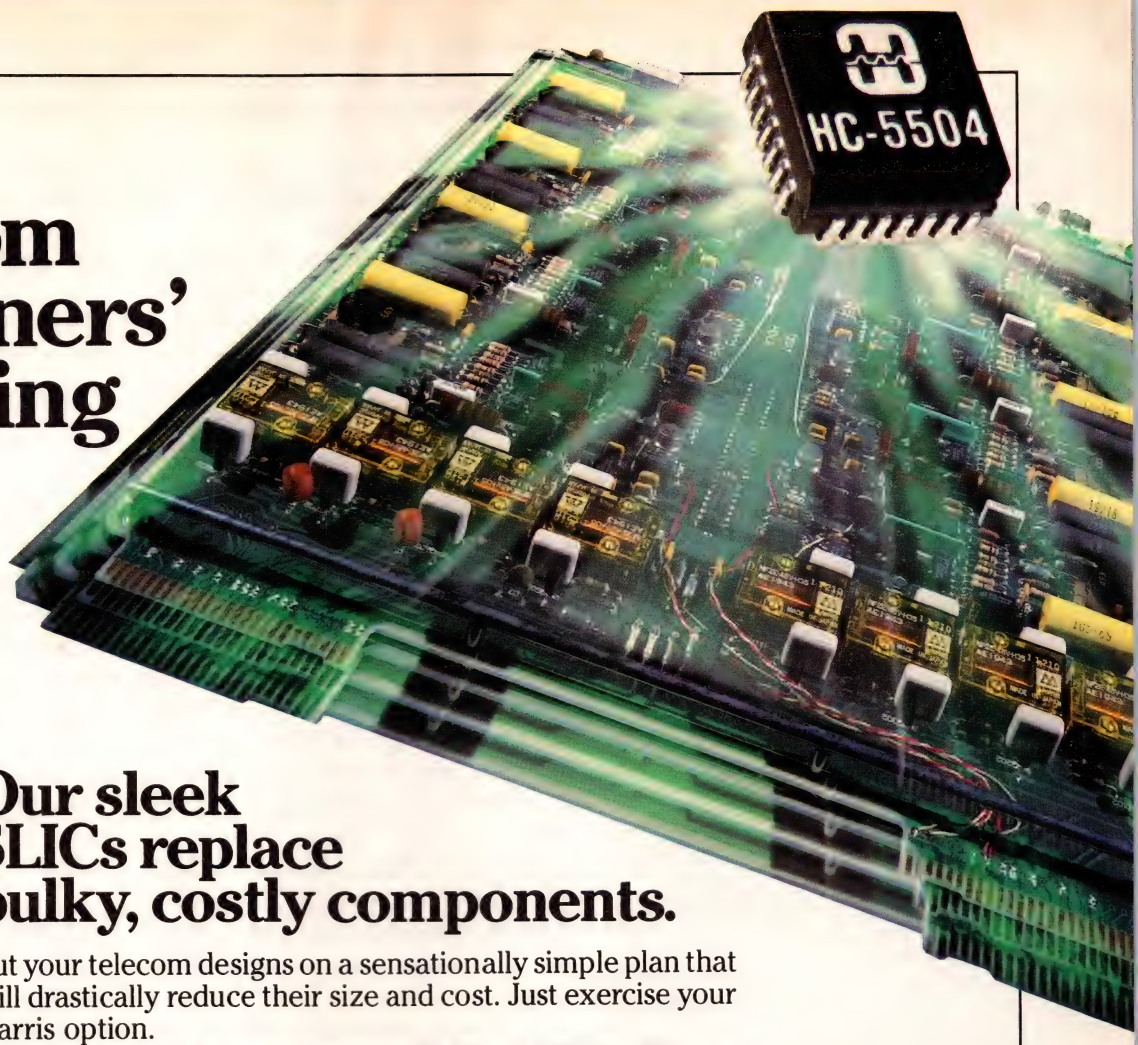
Although Rockwell's DSP approach raises power consumption, the company's DSP expertise can pay off in the form of better performance. The company has called upon the experience gained in producing 9600-baud modem ICs to create a modem that communicates at the more reliable 1200-baud rate. The key to improved performance is the modem ICs' autoadaptive equalization, which provides for operation under bad line conditions. You cannot incorporate this feature into a modem IC that's made of passive components.

In general, you will have difficulty comparing modem ICs on a performance basis. Autoadaptive equalization clearly improves performance, but in other respects, most modem-IC specs defy comparison. Such specs as dynamic range and carrier offset would ordinarily provide meaningful information, but no two manufacturers determine the specs in the same manner. This in-



Two signal processors (IC_2 and IC_3) *and an integrated analog chip (IC_1) form Rockwell's R2424DS 2400-baud, 3-chip modem.*

Telecom Designers' reducing plan:



Our sleek SLICs replace bulky, costly components.

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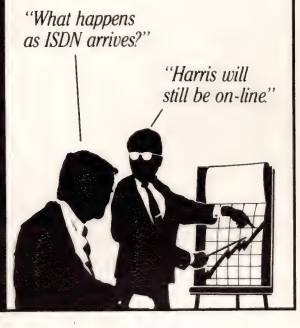

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TECHNOLOGY UPDATE

determinacy is even more of a problem for 2400-baud modem ICs than for 1200-baud devices.

Until some standard methods for specifying modem ICs emerge, you will be better off conducting a hands-on evaluation of each modem that may meet your requirements. You can buy evaluation-board modems from each manufacturer and test them in the lab and in operation over actual phone lines.

Market may bypass 2400 baud

The market for 2400-baud modem ICs may never grow to the size of that for 1200-baud devices. Although 1200-baud transmission quickly made 300-baud transmission obsolete, you shouldn't expect similar events to establish 2400 baud in place of 1200 baud. The large amounts of data required by the graphics industry could make 9600-baud transmission over dial-up lines the next major step in communications.

Rockwell currently offers the only complete, integrated modem-IC chip set for 2400-baud communication. The R2424DS is a 3-chip set. The company also offers the 1200-baud R1212DS 3-chip set. The two sets are identical except for the communication speed. You can buy the chip sets in versions that meet domestic or international standards.

The three chips in each set include two custom signal-processing chips and an integrated analog chip. The R1212DS costs $56, and the R2424DS sells for $85 (1000). The correlative chips in each set occupy the same amount of space on a pc board, and Rockwell provides you with a schematic that allows you to design one board for a 1200- or a 2400-baud modem.

Silicon Systems offers an integrated analog IC suitable for use in a 2400-baud modem. Customers must combine the $25.93 (1000) SSI 214 with a commercial DSP μP. Silicon Systems provides firmware support to help customers develop code for the DSP μP.

Manufacturers of DSP μPs claim that modem ICs—at least in their current form—will become obsolete as DSP technology advances. Modem-IC manufacturers concede that higher communication speeds may prompt increased use of DSP ICs, but they maintain that such functions as the bandsplit filter will continue to be rendered in analog circuitry. **EDN**

Article Interest Quotient
(Circle One)
High 503 Medium 504 Low 505

For more information . . .

For more information on the modem ICs discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Advanced Micro Devices Inc
Box 3453
Sunnyvale, CA 94088
(408) 732-2400
Circle No 670

Fairchild Semiconductor Corp
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Mountain View, CA 94043
(415) 962-3812
Circle No 671

Micro Power Systems Inc
3100 Alfred St
Santa Clara, CA 95054
(408) 727-5350
Circle No 672

Rockwell International
Semiconductor Products Div
Box C
Newport Beach, CA 92658
(714) 833-4700
Circle No 673

Sierra Semiconductor Corp
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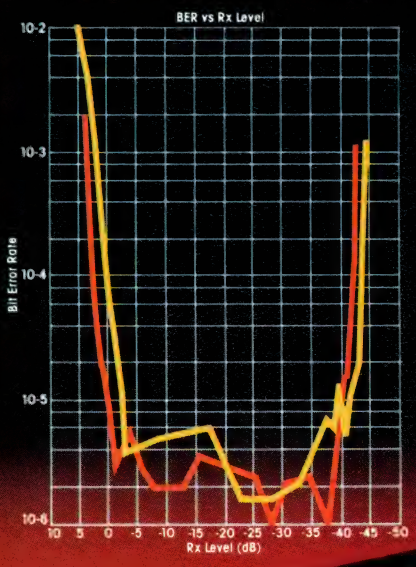

Leaving the Other SINGLE CHIP Modems Far Behind

Silicon Systems now leaps far ahead of all the breakthrough claims of lesser chips with the only family of modem IC's with "upward design capability." This new SSI modem family covers the entire Bell and CCITT range of full-duplex split-band modem standards, from 300 to 2400 bits per second—and out-performs the competition. Now you can design your system hardware and software with this family in mind and enjoy the benefits of total compatibility between the three major single-chip modem IC's—the SSI K212, the SSI K222, and the SSI K224.

Start with the K212 and Move Up to the K222 or K224.

The SSI K212 is the finest Bell 212A one-chip modem available today. It ties directly into such microprocessors as the 80C51 through a standard bus, without requiring a special controller chip. And if you are anticipating the need for a V.22/V.21 1200 bps modem IC or a V.22 bis 2400 bps, the SSI K222 or the SSI K224 will meet your needs. Design in an SSI K212 now and plug in an SSI K222 or a K224 later. Plug it into the same holes in the same hardware using the same software, and you can take advantage of the industry's only no-penalty upward-design feature in modem IC's.

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- Basic feature sets available in firmware
- Demo boards available for characterization

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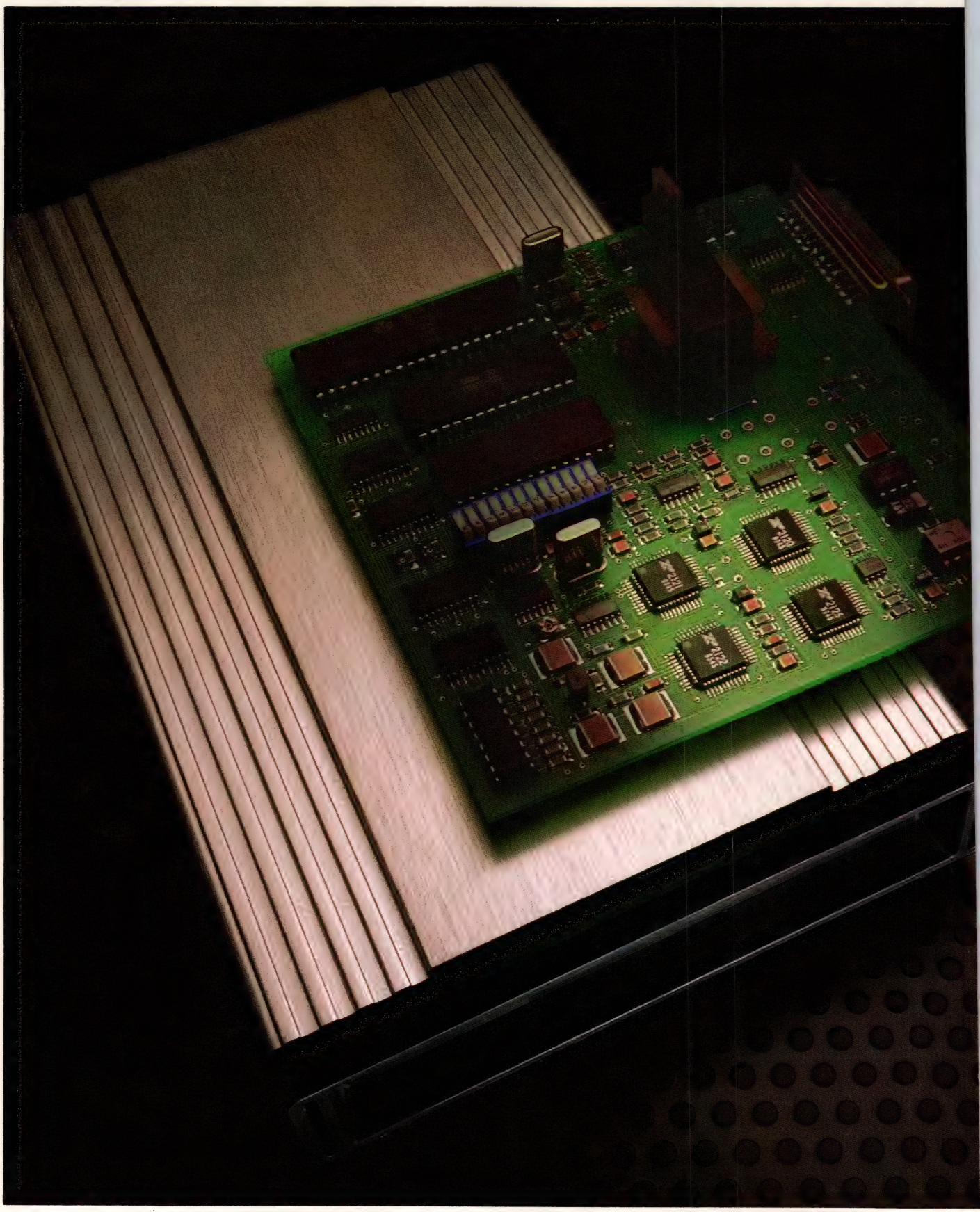

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With AT&T divesture, the likelihood of getting worst case line conditions has increased considerably. At EXAR we feel that modems must operate reliably under all the harsh conditions of the telephone network. These conditions include:

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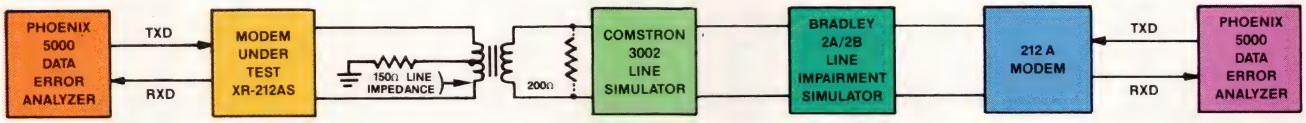

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Device	Function	Application
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XR-2122	212A demodulator	
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XR-2126	212A/V.22 filter	
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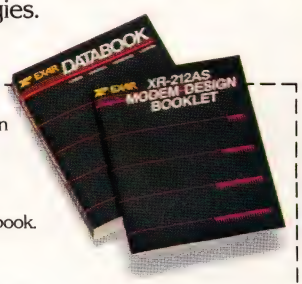

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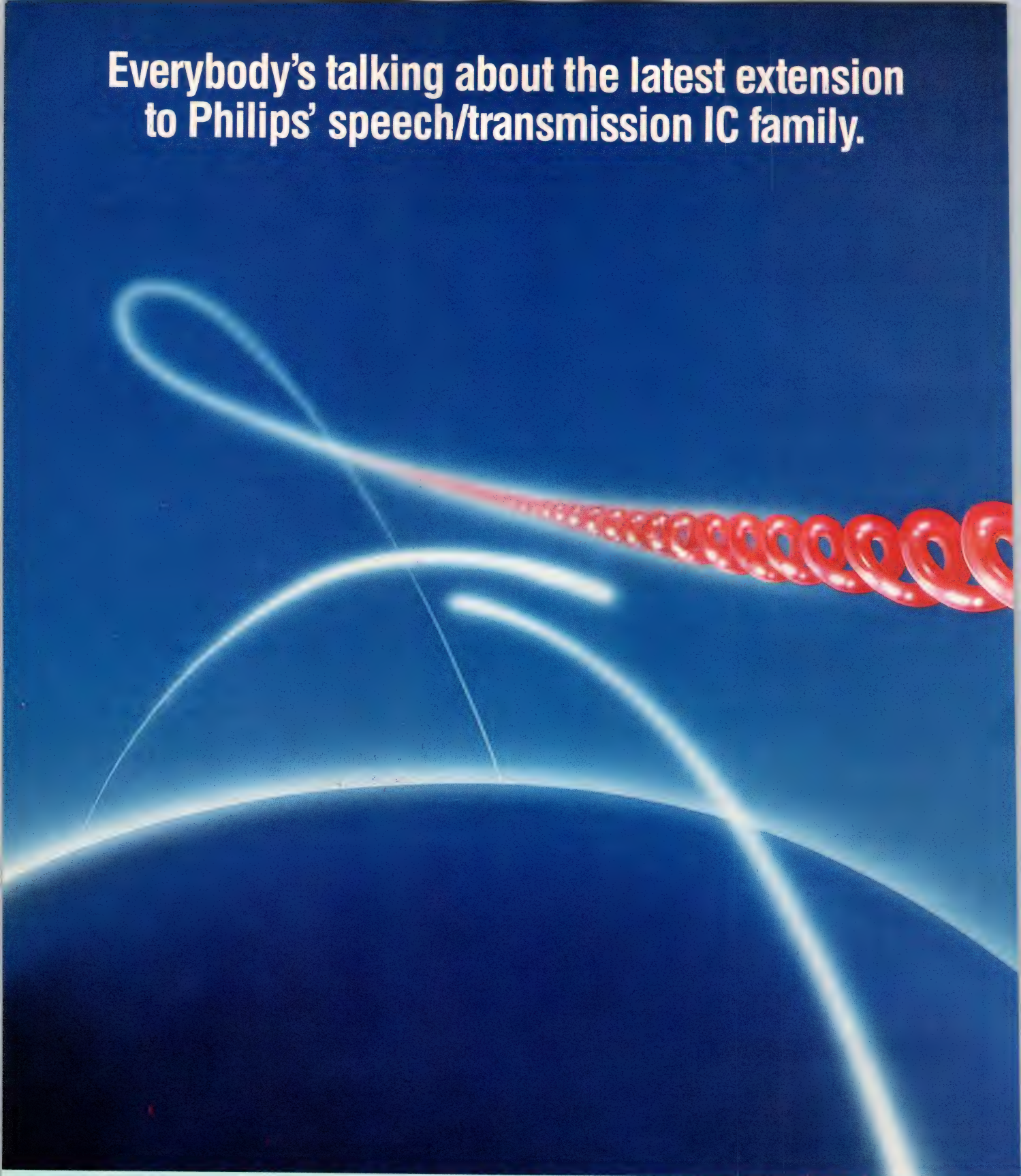

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CIRCLE NO 114

Versatile add-in boards acquire and process video images and graphics in real time

Jon Titus, *Senior Editor*

Add-in boards that let computer systems acquire video images and process them in real time shouldn't be confused with boards that simply digitize an image and store it in memory for the computer. Image-processing boards include video-output and frame-storage sections as well as the video-input section that enables digitization; moreover, they manipulate the video information on their own with little or no interaction by the host computer (**Fig 1**). Add-in boards are capable of processing steps spanning simple threshold adjustments to complex math-intensive filtering operations. Several boards also furnish graphic-overlay capabilities, which let you mix graphics, text, and processed images.

The boards range in complexity from the all-in-one single-board image processors available from Matrox and Epix to a set of seven sophisticated boards available from Datacube. This set of image-processing boards partitions basic image-digitizing and -display circuits, as well as memory, on one card. Additional cards supply the processing and circuits and the extra memory that stores images and processed results. The diversity of image-processing boards available offers choices that range from a 1- or 2-board system for a small computer such as an IBM PC/AT to a multiboard system for a VME Bus computer (**Table 1**).

External buses free CPU

To maintain real-time operation, almost all image-processing operations must take place without involving the host computer's bus. Thus, multiboard image processors must communicate over high-speed buses that are set up specifically for interboard communications. Data Translation supplies two input and output ports that link its image-digitizing and image-processing boards. Datacube's Maxvideo boards can provide as many as eight connectors for external interboard timing and data-bus signals.

Although the Matrox MIP-512 supplies all the image-digitizing and -processing circuits on one board, it also provides external connections that let you expand the board in applications that require more than eight bits per pixel. Imaging Technology, on the other hand, provides its interboard data lines on the VME Bus P2 connector instead of running cables between boards.

All image-processing boards acquire data from a variety of standard video sources. An example of such a source is a 60-Hz TV camera, which provides either RS-170 or

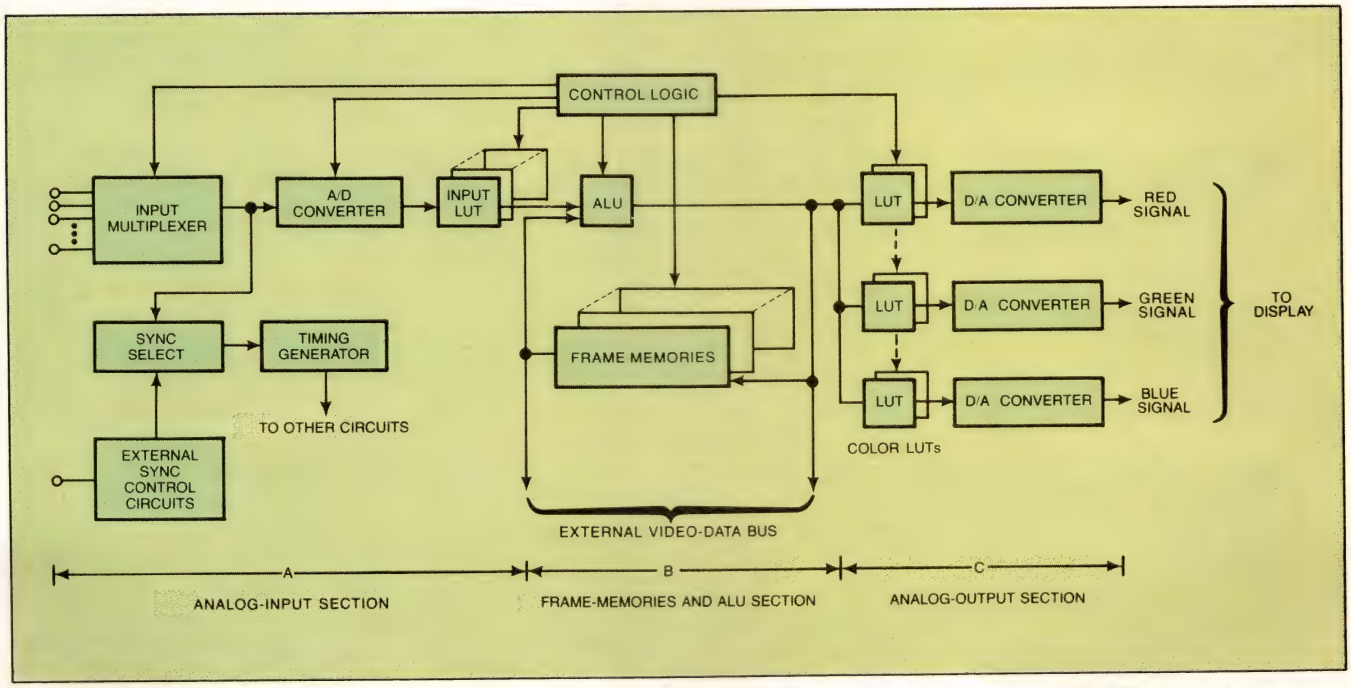

Fig 1—Image-processing systems contain three basic sections: *an analog-input section, a frame-memories and ALU section that processes the image data, and an analog-output section. You can find these functions on as few as one to as many as seven plug-in boards.*

RS-330 video-output signals. The boards also accept 50-Hz CCIR (International Radio Consultative Committee) video signals. When digitizing these standard video signals, they derive their timing signals directly from the composite-sync signals within the video information.

Synchronize external signals

Not all video information is available in one of the CCIR or RS formats, so each board also lets you synchronize its data-acquisition timing to external signals. Such external sync signals simplify the task of acquiring data from slow-scan video systems such as medical-imaging instruments.

For example, the Data Translation DT2851 Frame Grabber board accepts three external synchronizing signals: scan trigger, clock enable, and pixel clock. The scan-trigger signal initiates an image scan, and the pixel clock establishes the pixel-digitizing rate. The clock-enable signal differentiates between active-video and blanking times when video data isn't available.

Signals from VCRs (video cassette recorders) require special processing: VCRs are notorious for head dropout, which causes aberrations in their horizontal-sync signal. With the exception of Datacube's Digimax, all image-digitizing circuitry provides an internal PLL circuit that locks onto the sync signals and restores the timing information for the digitizing circuits.

TABLE 1—COMPARISON OF IMAGE-PROCESSING BOARD CAPABILITIES

COMPANY	BOARD FAMILY	SOURCE TYPES	NUMBER OF VIDEO SOURCES	INPUT LUTs	IMAGE SIZE (PIXELS)	NUMBER OF IMAGES	REPRESENTATIVE PROCESSING OPERATIONS AND FUNCTIONS
DATACUBE	MAXVIDEO SERIES	RS-170 CCIR	8	8	512×512 OR 512×384	3	SCROLL, PAN, ZOOM CONVOLUTION FIR FILTER HISTOGRAM STANDARD ALU 8×8-BIT MULTIPLIER BARREL SHIFTER
DATA TRANSLATION	DT2851 AND DT2858 (SET)	RS-170 CCIR RS-330 NTSC PAL SLOW-SCAN	1	8	512×512 OR 512×480	2	AVERAGE SCROLL, PAN, ZOOM CONVOLUTION WINDOWS STANDARD ALU PIXEL CURSOR
	DT2651 AND DT2658 (SET)	RS-170 CCIR RS-330 NTSC PAL SLOW-SCAN	4	4	512×512 OR 512×480	2	AVERAGE SCROLL, PAN, ZOOM CONVOLUTION WINDOWS STANDARD ALU PIXEL CURSOR
EPIX	4MEG VIDEO	RS-170 CCIR RS-330	4	1	VARIABLE	VARIABLE	TMS32020 CPU OPERATIONS
IMAGING TECHNOLOGY	SERIES-100	RS-170 CCIR RS-330 VCR	3	16	512×512 OR 512×480 (12-BIT STORAGE)	1	AVERAGE SCROLL, PAN, ZOOM WINDOW SPIN COMPENSATION
	SERIES-150	RS-170 CCIR RS-330	4	16	512×512	2	16 ALU OPERATIONS 4×4- AND 3×3-PIXEL CONVOLUTION 16×1-PIXEL FIR FILTER 8×8-BIT MULTIPLIER BARREL SHIFTER
MATROX	MIP-512	RS-170 RS-330	4	16	512×512 512×480	1	AVERAGE SCROLL, PAN, ZOOM CONVOLUTION STANDARD ALU
RECOGNITION TECHNOLOGY	AS501M AND PX501M (SET)	RS-170 CCIR VCR	4	4	512×512	9	16-BIT ALU 8×8-BIT MULTIPLIER BARREL SHIFTER CONVOLUTION FILTERING
	AS401V AND PX401V (SET)	RS-170 CCIR RS-330	4	4	512×512	4	SCROLL, PAN, ZOOM 16-BIT ALU 12×12-BIT MULTIPLIER CONDITIONAL PROCESSING

Color images are important in some industries, such as food processing, but most image-processing systems for small computers operate with black-and-white images. You can digitize a color image, but the boards operate with 256 intensity levels (shades of gray) instead of the real colors.

Filter color signals

If you're acquiring an image from a source that supplies a color-video signal, you must filter the signal to remove chromatic data. Several boards let you filter either the 3.58-MHz NTSC (National Television System Committee) or 4.43-MHz pal (phase-alternation line) chromatic signals so only the intensity, or luminance, information from the video source reaches the unit's A/D converter.

For example, the Datacube Digimax board lets you choose one of four software-selectable filters: three antialiasing lowpass filters and a full-bandwidth flat-response filter. Data Translation's Frame Grabber boards include a notch filter for either NTSC or pal signals. You must carefully select the filtering operation so it doesn't distort the resulting luminance signal.

With one exception, the video data-acquisition circuits include multiplexers that let you select one of several signal sources under software control. Thus, you don't need an image-digitizing board for each camera or other video source you work with. Although the Data

OUTPUT LUTs	OUTPUT TYPES	NUMBER OF AVAILABLE COLORS (OUT OF 16M)	SOFTWARE SUPPORT	COMPUTER BUS	PRICE	NOTES
8	RS-170	256	YES	VME	FROM $3700	• MANUFACTURER PROVIDES SEVEN BOARDS FOR IMAGE-PROCESSING AND STORAGE TASKS.
8	RS-170 CCIR	256	YES	PC/AT	$4490	• SOFTWARE PACKAGE AVAILABLE IN BASIC, C, PASCAL, FORTRAN, OR MACROASSEMBLER ($995). • MULTIPLEXER ADD-ON BOARD EXPANDS INPUT TO EIGHT SOURCES.
8	RS-170 CCIR	256	YES	Q	$4590	• DT2651 STORES TWO IMAGES; DT2658 INCLUDES A 16-BIT IMAGE MEMORY.
1	RS-170 CCIR RS-330	256	YES	PC	$3995	• USERS CONFIGURE 4M BITS OF MEMORY FOR EACH TYPE OF APPLICATION.
16	RS-170 CCIR	256	YES	VME Q PC/AT MULTIBUS I	FROM $3995	• INPUT LOOK-UP TABLES OPERATE IN SIX MODES UNDER PROGRAM CONTROL. • 4-BIT OVERLAYS ACCOMMODATE GRAPHICS AND TEXT.
16	RS-170 CCIR	256	YES	VME	FROM $4990	• VIDEO MEMORY INCLUDES A 512×512-PIXEL 16-BIT ARRAY FOR INTERMEDIATE RESULTS.
8	RS-170	256	YES	MULTIBUS I	$2995	• C SOFTWARE LIBRARY OF IMAGE-PROCESSING ROUTINES.
2 OR 4	RS-170 CCIR	512	YES	MULTIBUS I	FROM $5990	• USERS SELECT 512- OR 256-BYTE COLOR LOOK-UP TABLES. • SEPARATE BOARD (DS-501M) STORES IMAGES.
4	RS-170 CCIR	1024	YES	VME	FROM $6490	

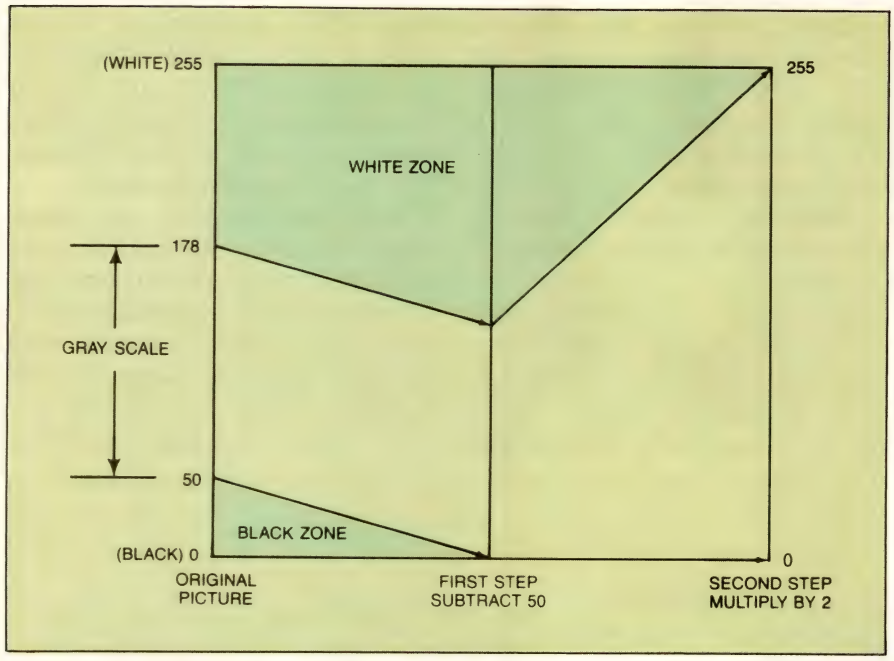

Fig 2—A typical look-up table operation *involves subtracting an offset value and then expanding the scale by multiplying by 2.*

Translation DT2851 furnishes only one video-input channel, an optional half-height DT2859 add-on board ($395) lets you multiplex one of eight video signals to the digitizer board.

High-speed 8-bit flash A/D converters are common to all image-digitizing circuits, although the Datacube Digimax board offers a 6-bit A/D converter as an option. Digitizing takes place in real time, requiring 1/30 of a second to digitize a complete image. Keep in mind that although a TV camera completes a scan in 1/60 sec, a complete image frame requires two interlaced scans.

After digitizing the information, a digitizer board passes the binary image data to a look-up table (LUT), which can manipulate the image before the board processes it further or stores it. The 8-bit pixel data forms the LUT's address and in turn the LUT puts out its contents for the next processing section. Typically the LUT is a high-speed RAM that you load with transformation information before the board acquires an image.

If you load each LUT's location with its corresponding address, passing the pixel data through the LUT has no effect. However, if you modify the LUT's contents by loading the first eight locations in the table with 0, pixel values between 00000111_2 and 00000000_2 are all set to 0, or black. As a result, passing the video data through the LUT filters out the seven gray levels closest to black, converting them to black instead.

If an image-processing board provides a loop-back path that lets it pass a stored image back through its LUT, the table can perform multistep operations such as contrast enhancement **(Fig 2)**. During the image's first pass through the LUT, the LUT subtracts a threshold value from each pixel. During the second pass, the LUT expands the data to the full range of 256 values so that pixels in the image display a complete range of gray-scale values from white to black. Remember that the LUT doesn't do any math as such, it only substitutes one value for another.

To simplify LUT-type processing, manufacturers provide a bank of LUTs that you select via software commands. To perform a series of different transformations, you again load the necessary LUTs before you start processing data. Switching from one LUT to another as data passes through the system lets the computer rapidly change processing tasks. Typical LUTs contain 256 bytes—one per gray-scale, or intensity, value.

Useful processing operations don't all involve complex math operations that take a lot of time. For example, pan and scroll operations let you move the image horizontally or vertically, one pixel at a time. Pan and scroll registers let you set the starting points for each operation. The zoom operation lets you expand an area of interest; these operations are often limited to 2-, 4-, or 8-time expansions. Other zoom-expansion values are possible, but they require interpolating or weighting pixel values.

ALUs speed processing power

To perform more complex processing tasks, an image-processing board must rely on an ALU. By providing an ALU in the data path, a board can perform filtering, averaging, edge-detecting, and other math- or logic-intensive tasks that you program yourself or obtain from the manufacturer's image-processing software packages. For example, a highpass filter routine enhances small variations, and a lowpass filter routine removes noise. Each filtering task requires many math operations per pixel.

The ALU on the Matrox board and on the Data Translation and Datacube board sets provides 32 basic math and logic operations that correspond to those available from a 74181-type ALU chip. Although the operations are elementary, you can combine them under software control to perform complex tasks. Recognition Technology, on the other hand, includes a great deal of math and logic processing power on its PX401V pixel-processor board: a 16-bit plus sign ALU as well as a 12×12-bit multiplier circuit.

An alternate approach is to pro-

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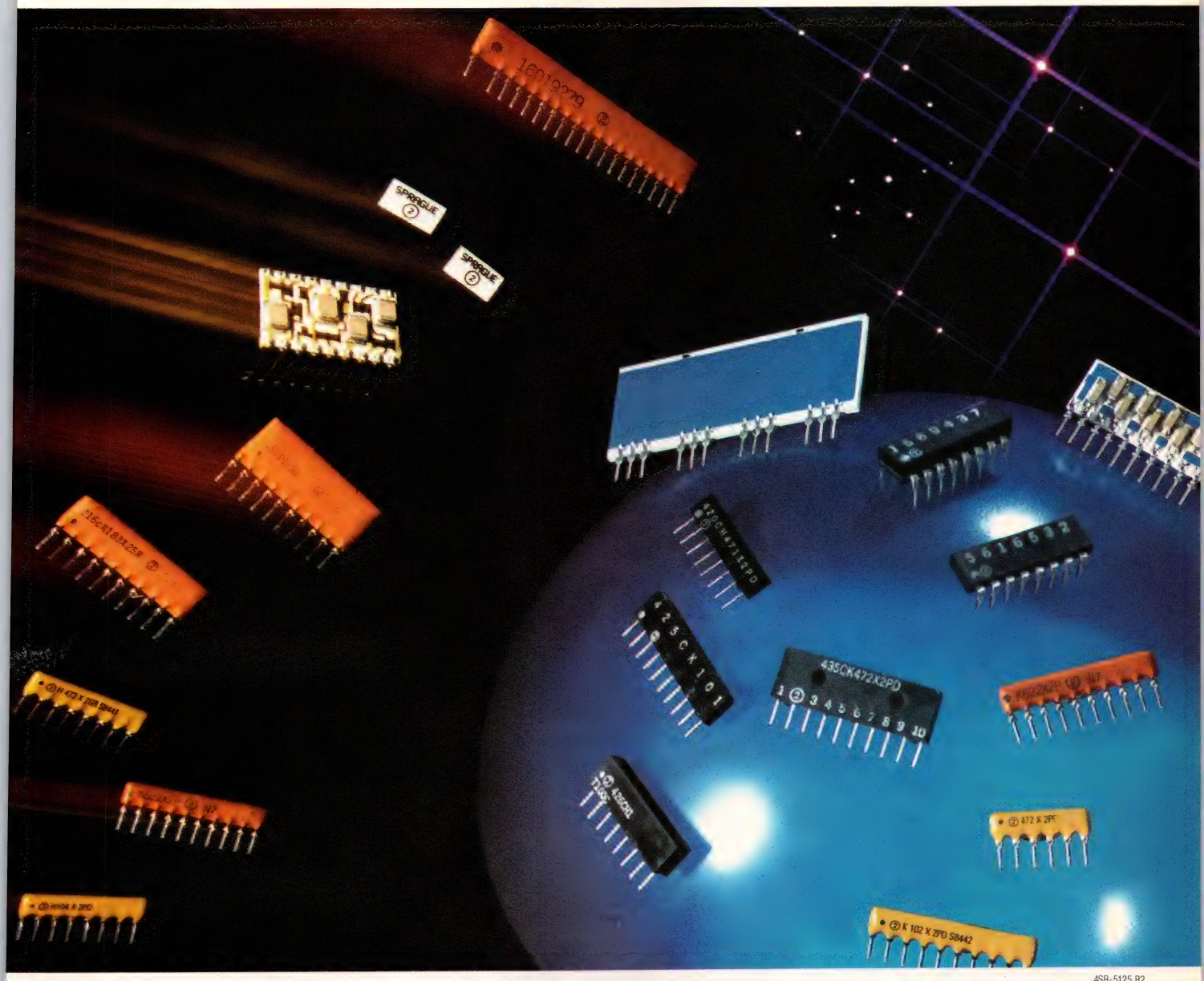

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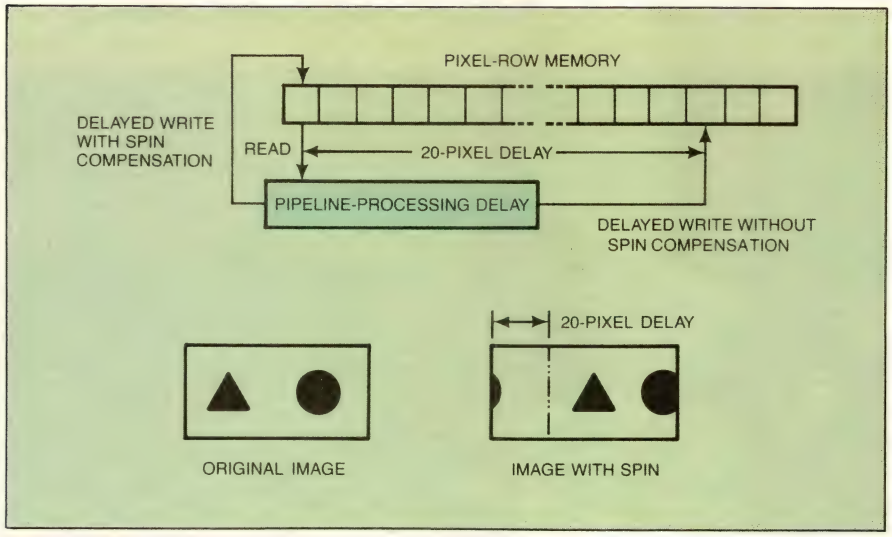

Fig 3—Pipeline-processing operations will introduce spin *in an image unless the image-processing hardware accounts for it and replaces a processed pixel back at its original address.*

vide a board dedicated to a single processing operation. Datacube's pixel-processor board (VFIR) only operates on 10 pixel values at once, multiplying each by a coefficient and summing the results. The specialized board functions as either a 10-point finite-impulse-response (FIR) filter or a 3×3-pixel 2-dimensional convolver. To maintain accuracy throughout its processing operations, the board supplies 16-bit results.

Datacube also offers a general-purpose signal-processing board (MAX-SP) that supports eight standard math and logic operations. The MAX-SP board manipulates 16-bit operands and produces a 17-bit result plus an overflow status bit.

Instead of supplying an ALU, which might require extensive and unique software support, Epix furnishes a TMS32020 digital signal-processing (DSP) chip as the central processing unit on its 4Meg-Video board. The board includes 8k bytes of data- and program-storage space for the TMS32020. You load your programs from the host computer into the TMS32020's program memory before you start a video-processing task.

Image-processing boards for the VME Bus *from Recognition Technology offer video digitizing and output, pixel processing, and image storage.*

All image-processing boards require RAM for image storage. Boards from Matrox, Data Translation, and Epix include storage space on their image-digitizing boards, but board sets from Datacube, Imaging Technology, and Recognition Technology require separate image-storage boards. Besides storing images, the boards also set aside RAM addresses for LUTs and for storing intermediate results. Most manufacturers supply storage for an image of 512×512 pixels (8-bit pixel resolution), or 256k bytes. Depending on camera and display-screen resolution, boards may also offer storage arrays of 512×480 or 512×384 pixels.

Memory options include letting the host computer access the image-storage area and protecting the images from external-host write operations. Keep in mind that when the host computer directly accesses the image-storage space, the computer must give up an equivalent number of RAM addresses. Datacube's Framestore board stores three 512×512-pixel images, which occupy 832k bytes of storage in a VME computer system. The upper 64k bytes are set aside for onboard register addresses.

Because the control circuits scan through the display memory sequentially, a delay in processing a pixel causes the result to be offset from the original pixel's position when it's put in the memory **(Fig 3)**. Such a delay is particularly evident in systems that load pixels into a pipeline that provides the ALU with a steady stream of data for processing. To compensate for the delay-induced shift, or spin, in the image, the image-processing boards provide compensation internally by adjusting the image addressing.

To increase processing speed, Im-

16-bit 2901
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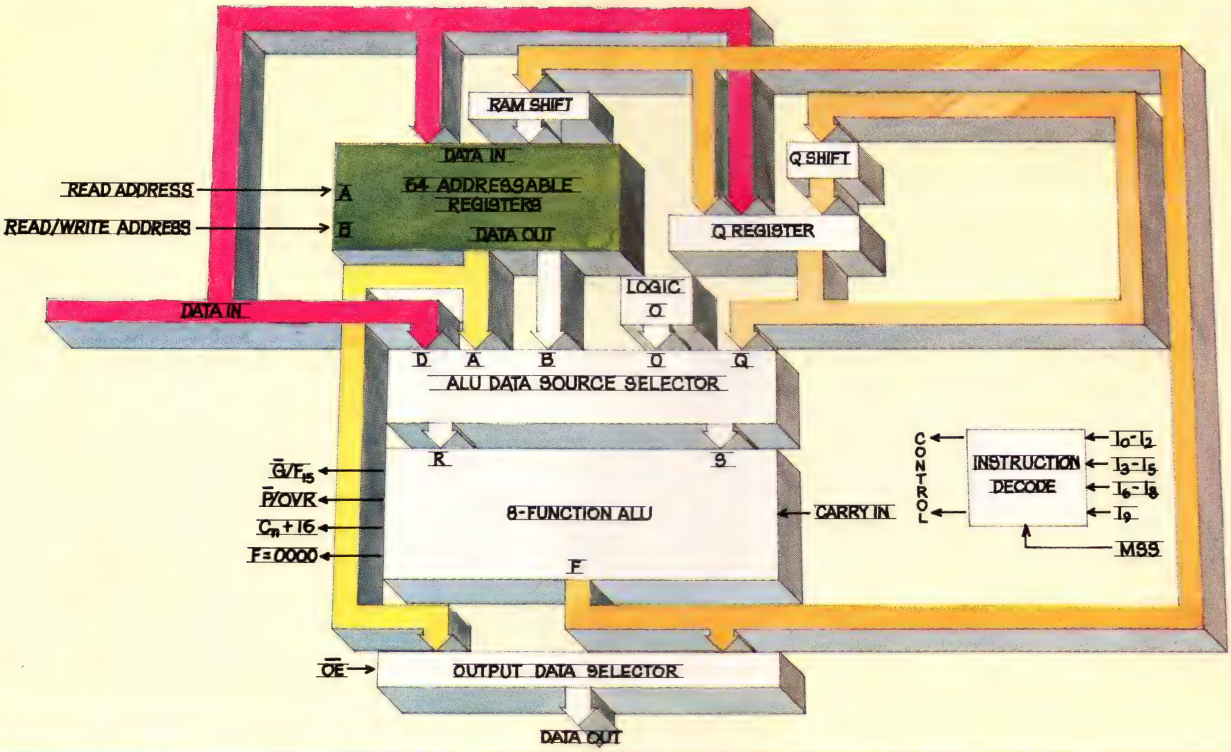

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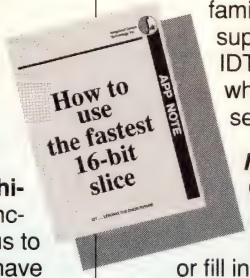

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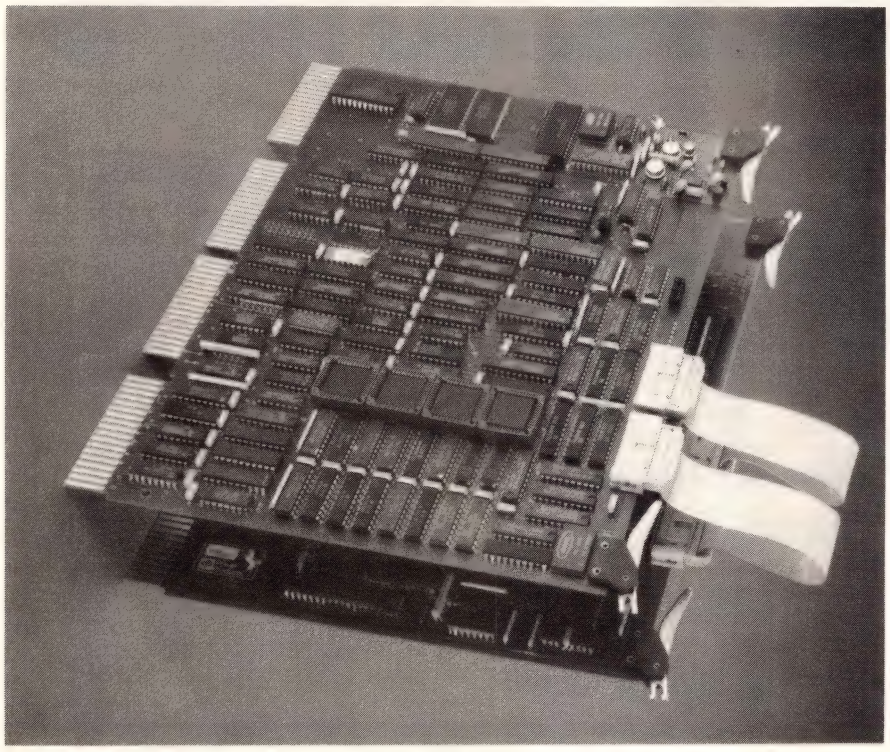

Boards for MicroVAX II systems, *which Data Translation offers, include a notch filter for either NTSC or pal signals.*

aging Technology provides an area-of-interest (AOI) mode in its Series-150 image-processing boards. The AOI mode lets you select a rectangular area for processing. Starting with the pixel location in the pan register, you move right in multiples of eight pixels. Vertical dimensions start with the scroll register's value and move down in increments of one pixel. When in the AOI mode, the ALU processes only the information in the rectangle you defined; it doesn't process the other pixels.

After processing an image in either an ALU or LUT, the image processor displays it in either 256 gray levels or 256 false colors (pseudocolors). Because the eye distinguishes more readily between color shades than intensity levels or gray levels, many applications use pseudocolors to detect slight changes in an image.

The image-processing boards' image-output section includes color LUTs that store 8-bit transformation tables for each color signal—red, blue, and green—that goes to your monitor. Because each of the three color LUTs receives an 8-bit address, you have a range of 2^{24}, or 16.7 million, possible colors. However, because each LUT receives the same 8-bit address, you can only access 256 different colors at a time.

Keep in mind that the colors depend on the values in the LUT and don't necessarily correspond to the colors—if any—in the original image. The boards provide for a bank of color LUTs, so you can preload several color palettes and use them as necessary. Each of the LUT's outputs drives a high-speed 8-bit D/A converter. The converters provide RS-170, RS-330, or CCIR-compatible signals as well as sync signals for a color display. The pixel aspect ratio is 4:3 for standard monitors, although the Matrox MIP-512 lets you choose a 1:1 aspect ratio as an alternative.

Add graphics and text

Boards in the Imaging Technology Series-100 family store images as 12-bit values in 512×512-pixel arrays. These extra four bit planes let you overlay graphics and text on video images by switching to a new set of color LUTs as you scan through the video data. You can load the graphic and text information into the extra four bits directly from the computer bus, or you can load it into one of the input LUTs for later combination with an image.

In many cases, you can connect image-processing boards in parallel to extend the processing capabilities to color images, with one color—red, blue, or green—per set of boards. Likewise, you can add boards in parallel to increase image-storage space or to create graphic and text overlays. **EDN**

For more information . . .

For more information on the image-processing boards described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

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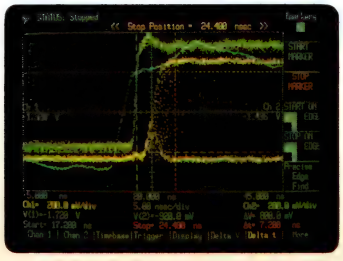

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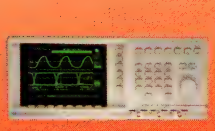

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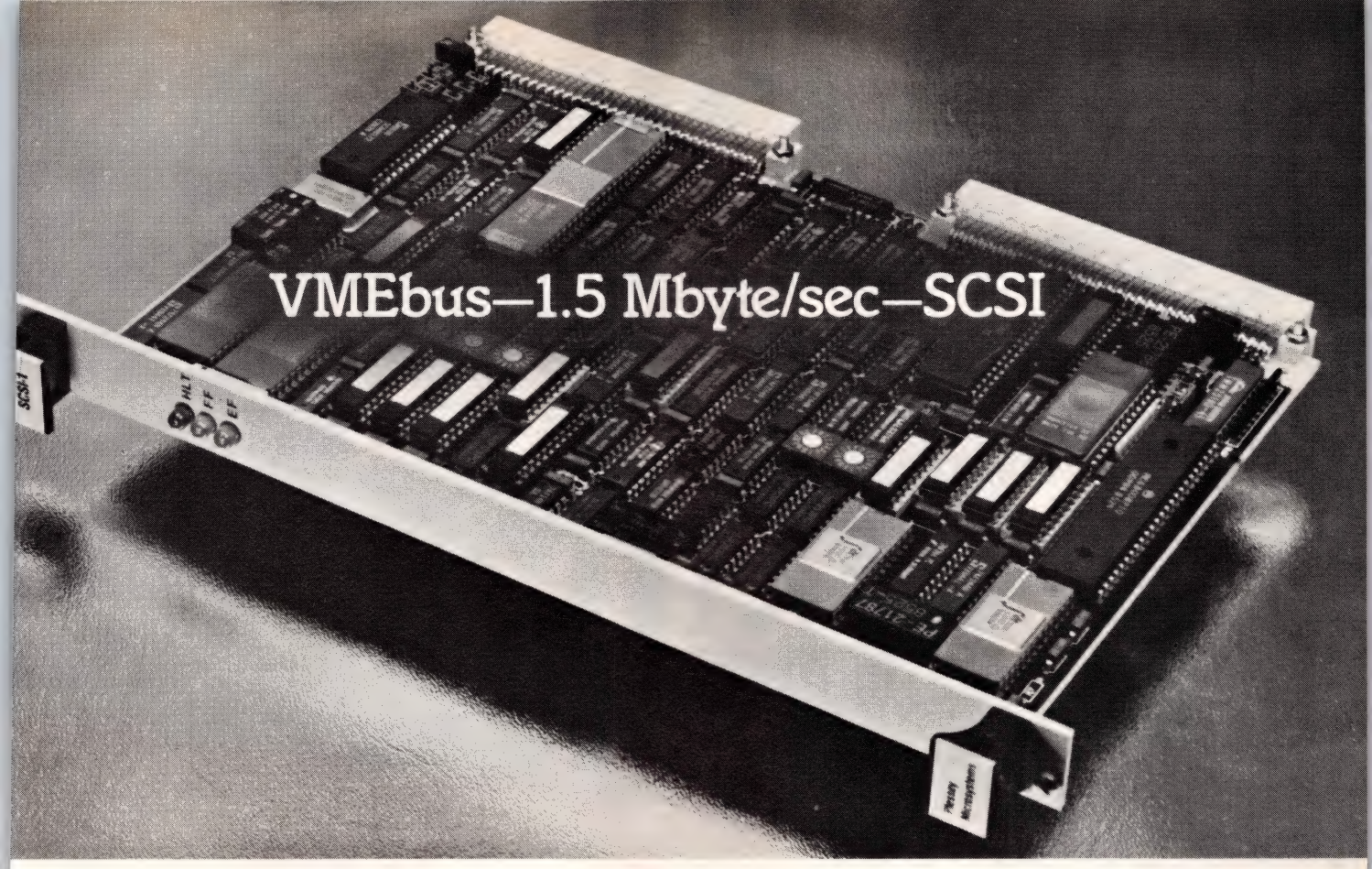

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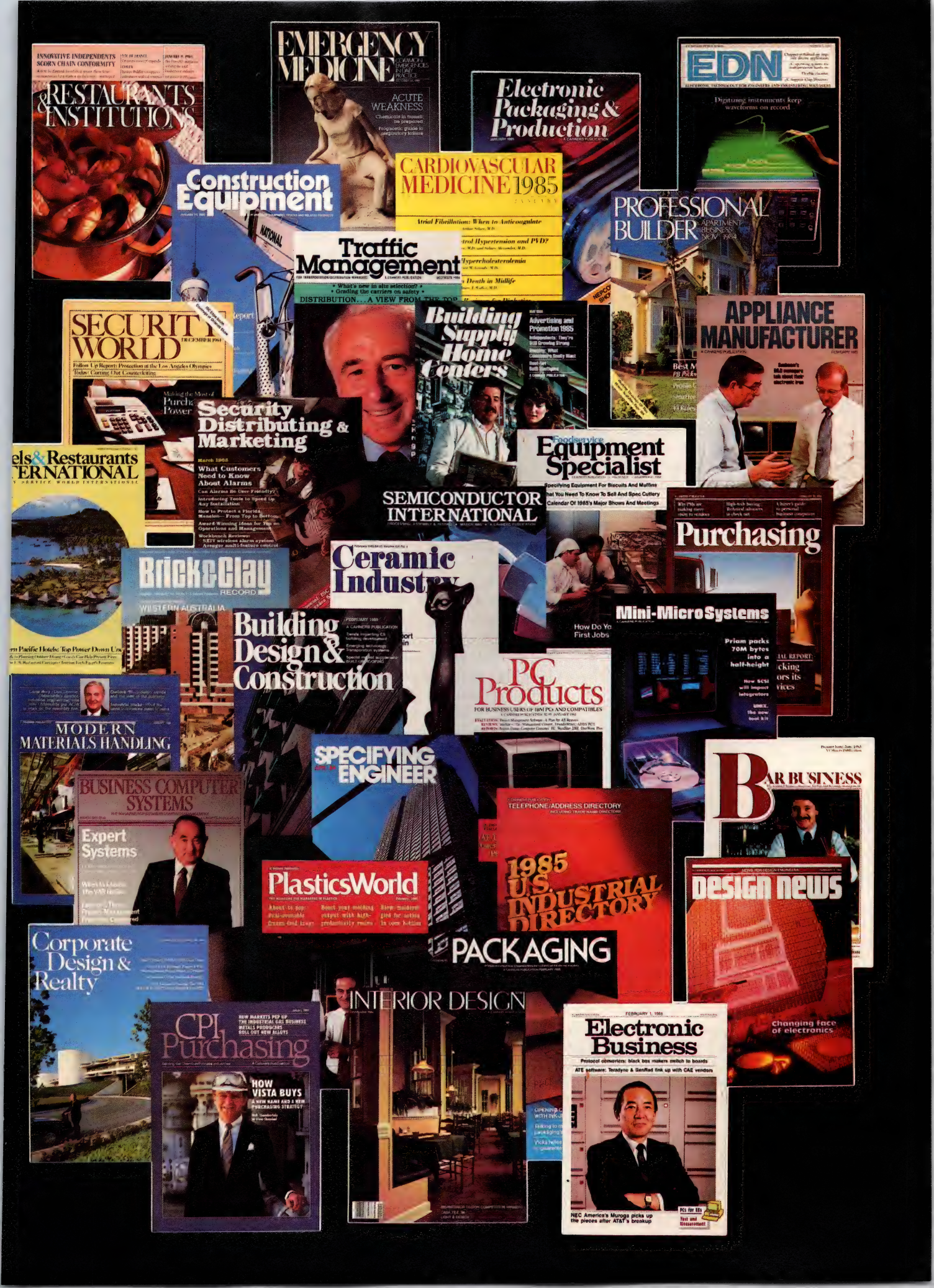
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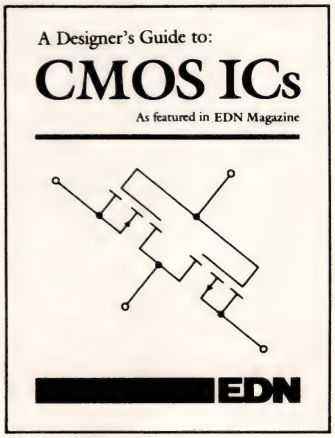

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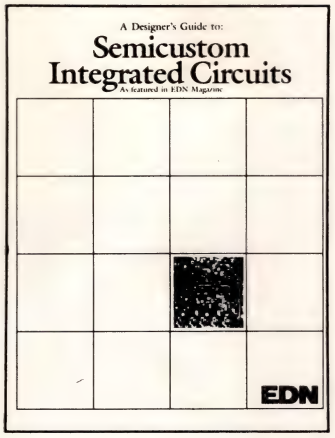

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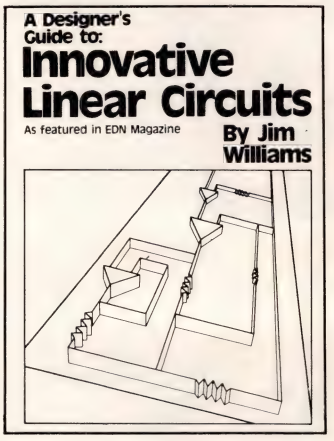

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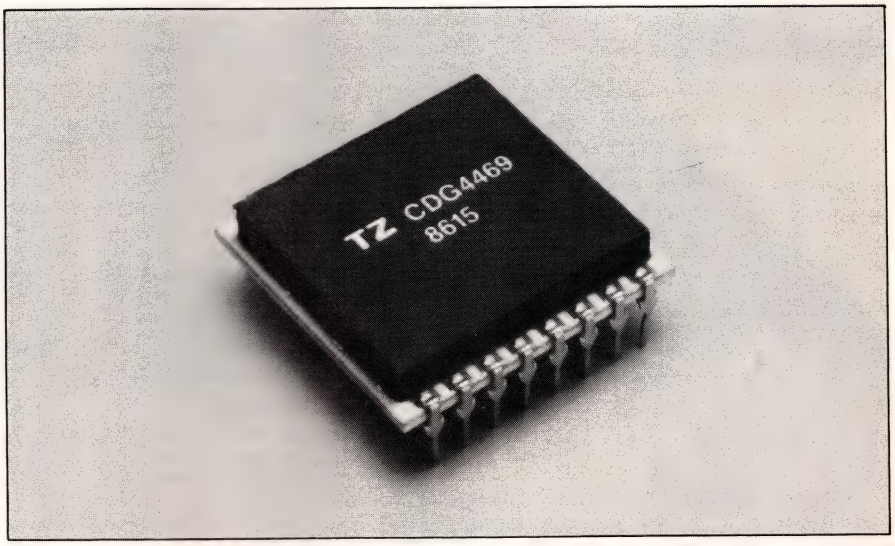
CMOS/DMOS-processed digital attenuator provides 256 steps in 0.5-dB increments

The CDG4469 hybrid attenuator IC uses CMOS logic and level-translation circuitry with lateral DMOS switches to control a ladder network of resistors. The IC provides 256 steps of attenuation in 0.5-dB increments. Added attenuation ranges from 0 to 127.5 dB. The device introduces 4.5-dB max insertion loss.

The attenuator, which accommodates analog input voltages as high as 6V rms, has a constant input impedance of 650Ω. The IC has a 15-MHz frequency range; it operates from ±6 to ±15V supply voltages. When operating from ±15V supplies, it dissipates 0.5 μW typ.

All inputs to the CDG4469 have diodes that protect the inputs against damage from high static voltages or electric fields. The manufacturer recommends, however, that you restrict input voltages to the specified ±8V absolute-maximum rating. The data sheet also advises you to connect all unused inputs to an appropriate logic level.

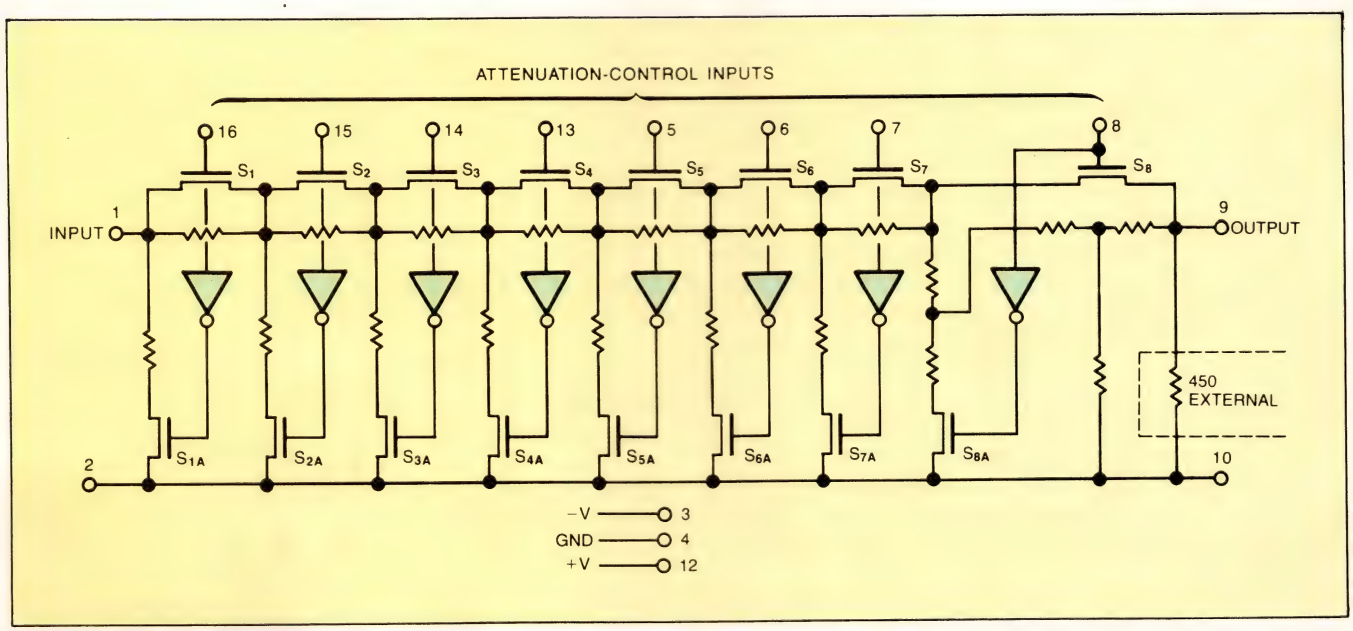


This 256-step, digitally controlled attenuator, *Model CDG4469 from Topaz Semiconductor, allows you to program attenuation in 0.5-dB steps. The device is useful for video attenuation, amplifier-gain control, variable-burst generation, and logarithmic D/A conversion.*

The hybrid attenuator comprises a single silicon chip mounted on a ceramic substrate. The chip integrates the CMOS logic functions and DMOS switching elements; the substrate carries the ladder network's trimmed resistors. The circuit comes in a DIP configuration having 0.9-in. row spacing. $23.50 (100).—***Bill Travis***

Topaz Semiconductor, 1971 N Capitol Ave, San Jose, CA 95132. Phone (408) 942-9100.

Circle No 729



CMOS logic and DMOS switches control a ladder network *in the CDG4469 digitally controlled attenuator. The device's input presents a constant 650Ω impedance to the driving source. Logic zero on the inputs turns S_1 through S_8 on and S_{1A} through S_{8A} off.*

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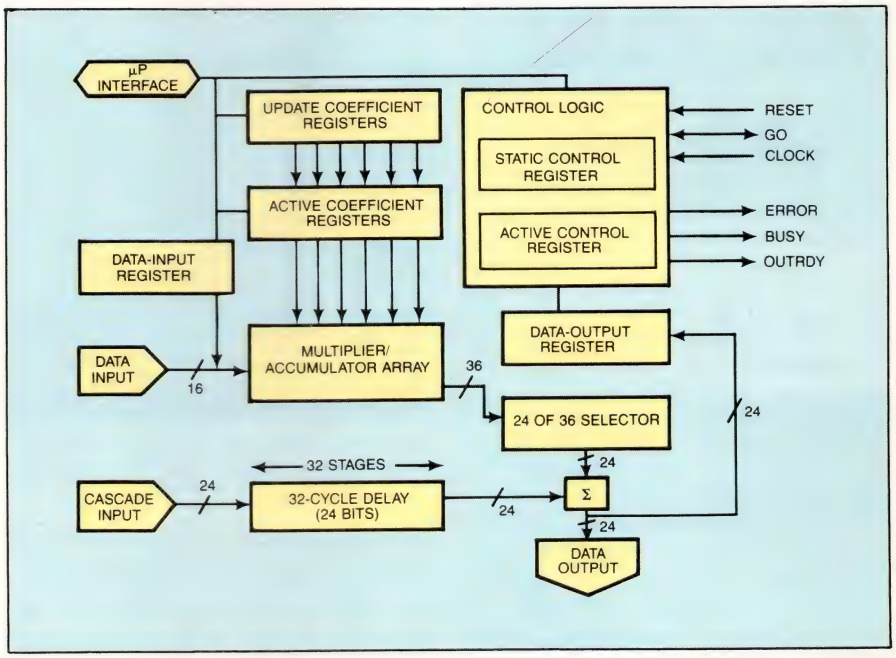
Cascadable DSP IC processes data at 10M samples/sec



The coefficient and control registers *of the IMS-A100 DSP IC appear to an external µP as a 128-word block of static RAM. You can use the µP interface to feed 16-bit data to the chip's 32 multiplier/accumulator stages and to interrogate the computed results.*

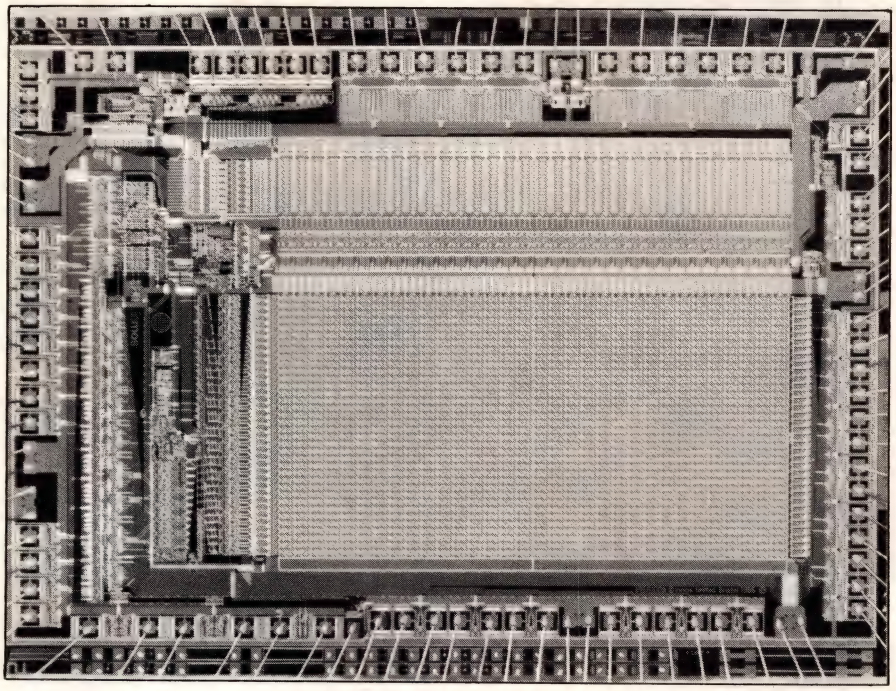
For high-speed processing of transversal filter functions, the IMS-A100 cascadable signal-processor IC integrates 32 multiplier/accumulator stages on a single chip. Each stage is capable of multiplying 16-bit data by 16-bit coefficients at a data rate of 2.5M samples/sec. For higher throughput, you can reduce the coefficient size to 12, 8, or 4 bits. For 4-bit coefficients, the chip's maximum data rate is 10M samples/sec.

The chip accumulates its 32 stages of 16×16-bit multiplication to 36-bit accuracy. A programmable barrel shifter on the output of the multiplier/accumulator array allows you to select a 24-bit word from these 36 bits. When you're operating a single device, this 24-bit word represents your final output. However, to build longer transversal filters, you can cascade devices by coupling the 24-bit output of one IMS-A100 to the cascade inputs of a second IMS-A100. An internal 32-stage, 24-bit shift register correctly synchronizes the cascaded result before it's added to the 24-bit barrel shifter output of the second IMS-A100.

The barrel shifter allows you to select four alternative positions for the 24-bit word in the 36-bit result, from bits 7, 11, 15, or 20 upwards. If you select the 24 bits between bit 20 and bit 43 (the top 8 bits are automatically sign-extended), you can cascade as many as 256 IMS-A100s without overflow.

The IMS-A100 stores coefficients internally in two independent memory areas, each of which contains 32 16-bit registers that you can randomly access via the IMS-A100's µP interface. A software-programmable control bit switches the two

PRODUCT UPDATE



Performing 32 16×16 multiply/accumulate operations *in 400 nsec, the IMS-A100 DSP chip achieves a processing rate of 80M fixed-point operations/sec.*

memory areas into the device's multipliers, so you can maintain one set of active coefficients while you update the device with a new set of coefficients.

This double buffering of the coefficients makes the IMS-A100 suitable for use not only in adaptive filters, but in complex number processing, because you can set the device to toggle automatically between a suitable set of real and imaginary coefficients on successive real and imaginary data values.

You access the coefficient registers and the device's control and status registers via the IMS-A100's μP interface; the registers appear as a 128-word block of static RAM having a 100-nsec cycle time. As an alternative to using the IMS-A100's dedicated data input and output ports, you can use the μP interface to access the 24-bit output word and to feed 16-bit data to the front end of the 32 multiplier/accumulator stages. You can, therefore, use the IMS-A100 as a computation engine for a host processor, feeding it data directly from the host processor or (using a DMA controller) from host-processor memory. All synchronization between the internal registers and the operation of the multipler/accumulators is handled by the IMS-A100, which frees the μP interface from any timing constraints.

Development support for the IMS-A100 comprises a simulator that runs on the company's IBM PC-based Occam development system. The simulator allows you to model single IMS-A100 designs or multiple IMS-A100 arrays. A plug-in board for the IBM PC, containing a Transputer and several IMS-A100s, together with sample application software, will be available soon.

Fabricated in CMOS technology, the IMS-A100 operates from a single 5V supply and has TTL-compatible I/O. It comes in an 84-pin pin-grid array and dissipates less than 1W. Sample devices cost around $500.—***Peter Harold***

Inmos Ltd, Box 424, Bristol BS99 7DD, UK. Phone (0272) 290861. TLX 444723.

Circle No 730

Inmos Corp, Box 16000, Colorado Springs, CO 80935. Phone (303) 630-4000.

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64k-bit static RAMs feature 25-nsec access times

Fabricated in 1.5-μm CMOS with a double-level-metal process, the MCM6287 and MCM6288 64k-bit static RAMs offer access times as low as 25 nsec. The 6287 is organized as a 64k×1-bit RAM, and the 6288 has a 16k×4-bit structure. A 4k×4 version, the MCM6268, is also available. No silicide is used in the double - level - metal fabrication process.

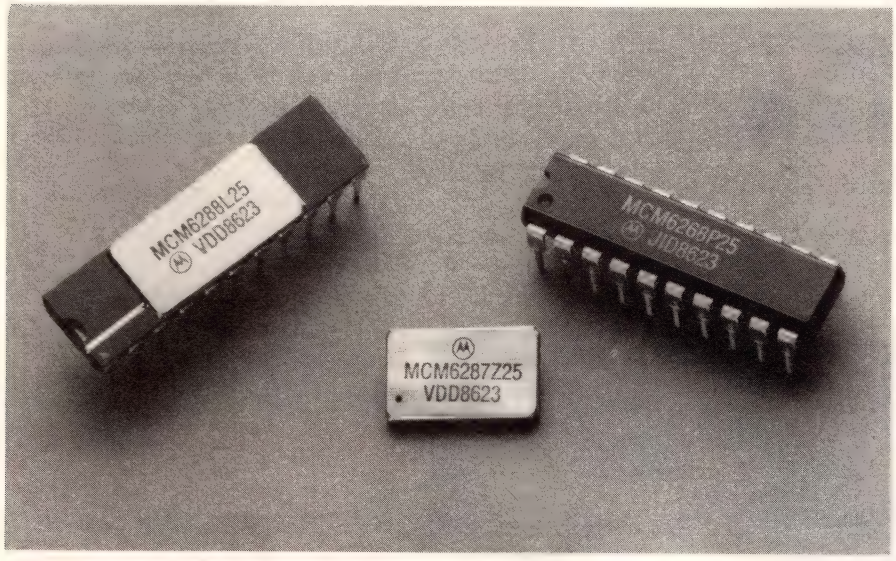
Using silicon-gate CMOS, the 6287 draws a maximum of 50 mA ac, and the 6288 draws a maximum of 80 mA ac. Both dissipate 1W max. Each IC includes a Chip Enable ($\overline{E}$) pin that is not a clock, but is instead a feature that reduces the IC's power requirements. In less than one cycle period after $\overline{E}$ goes high, the IC enters a low-power standby mode and remains in that state until $\overline{E}$ goes low again.

The chips' low access times are the result of a number of design techniques. The ICs employ a unique memory architecture that divides the array into several blocks so that only an eighth of the memory is activated at a time. For high-speed-signal development, the ICs contain very short bit lines that run horizontally. The column areas contain high-performance differential amplifiers, and the drive-to-load ratios for the entire data path constitute a uniform geometric progression.

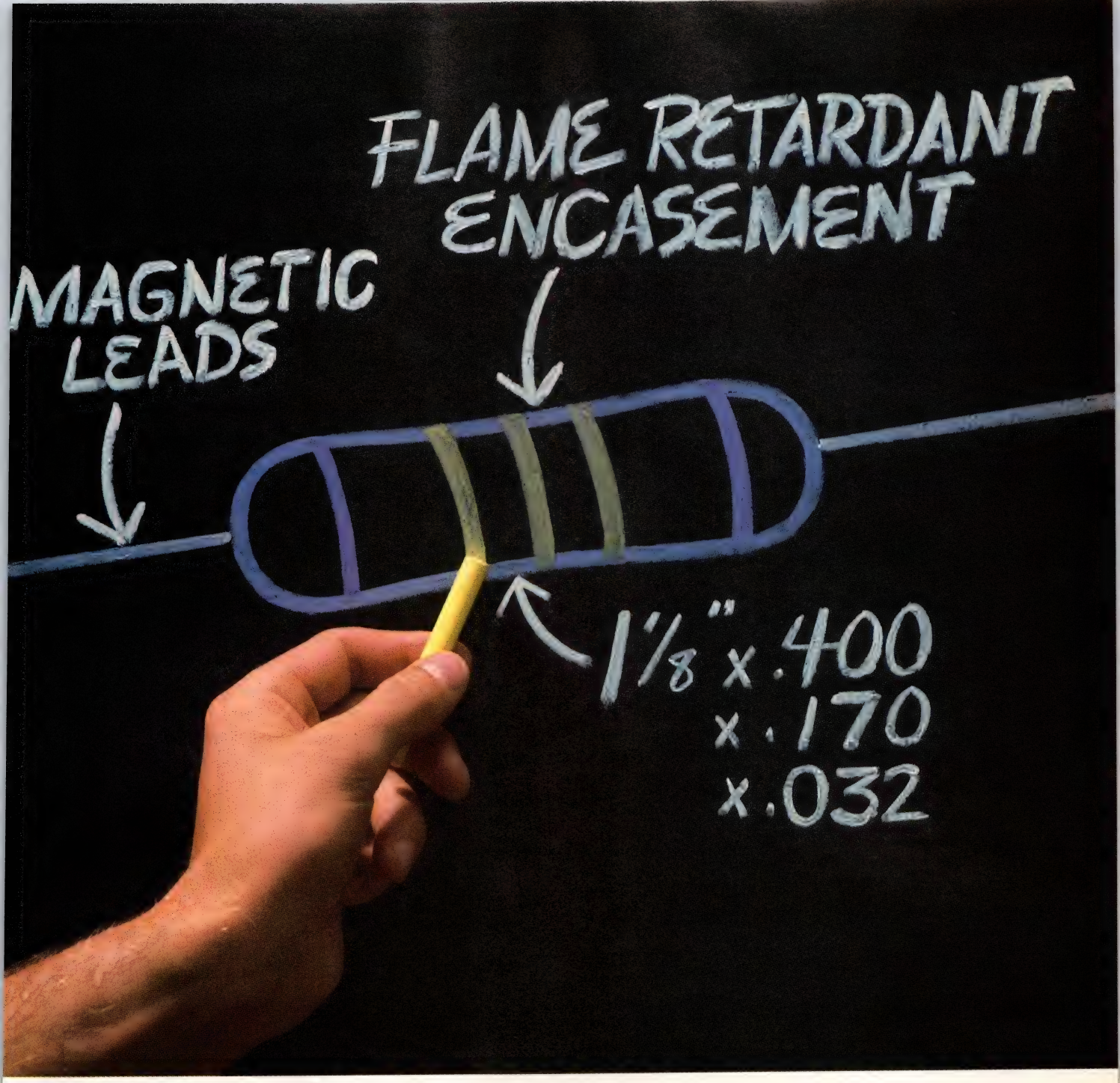
The ICs come in 300-mil, 22-lead ceramic sidebraze packages or plastic DIPs, or 290×490-mil ceramic leadless chip carriers. You can order a 45-nsec, 35-nsec, or 25-nsec access-time version of either chip. In quantities of 100, the 25-nsec 6287 (in the sidebraze package) costs $43, and the 45-nsec version costs $32; the 6288 (in a plastic DIP) is $54 for the 25-nsec version and $39 for the 45-nsec version.—***J D Mosley***

Motorola MOS IC Group, 3501 Ed Bluestein Blvd, Austin, TX 78721. Phone (512) 928-6000.

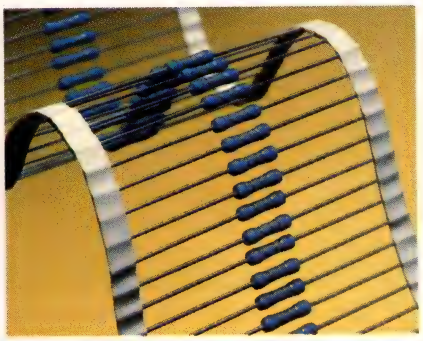
Circle No 727



Offering access times as low as 25 nsec, *the 64k-bit MCM6287 and MCM6288 and 16k-bit MCM6268 static RAMs have a static design that eliminates any need for external clocks or timing strobes.*



SPP Series wirewound resistors from TRW = Superior Performance & Price



SPP Series wirewound resistors from TRW are direct drop-in replacements for low-power molded resistors. Expanded wattages available — at a cost savings of 20-25% over alternatives!

In addition to the excellent cost-efficiency, SPP Series wirewound resistors are automatically insertable, have a flame-retardant encasement and excellent overload capabilities.

Available in 1, 2, 3 and 5 watts down to .1 ohm with 5% to 10% tolerance, this innovative series is just another example of TRW advanced technology keeping pace with today's critical requirements.

For more information contact your local TRW distributor. Or TRW Resistive Products Division, TRW Electronic Components Group, Greenway Road, P.O. Box 1860, Boone, NC 28607. 704.264.8861.

TRW

Resistive Products Division
TRW Electronic Components Group

CIRCLE NO 57

3½-in. disk drive has integral SCSI controller

The 8425S 3½-in. Winchester disk drive incorporates a SCSI controller and provides a capacity of 21.3M bytes (formatted). The manufacturer uses proven stepper and oxide-media technologies coupled with RLL 2,7 data encoding to push the drive's MTBF rating to 20,000 hours. Average access time for the drive is 68 msec; track-to-track access time is 15 msec. The 8425S drive dissipates an average of 12.5W.

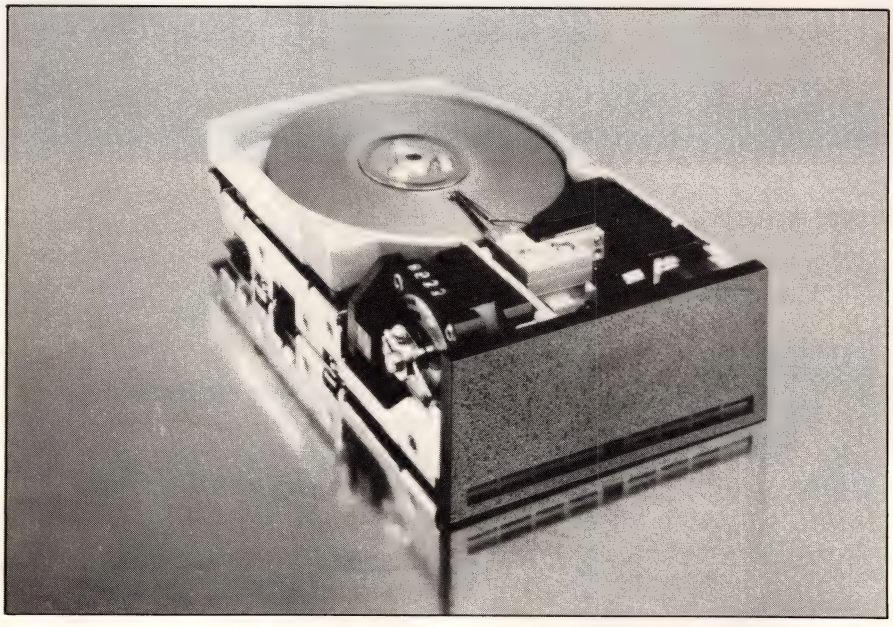
An integral controller permits host transfer rates of 1M bytes/sec and supports all commands in the SCSI common command set (CCS). Additional commands that the controller supports include Verify, Start/Stop, Seek Extended, Read Buffer, Write Buffer, Read Extended, Write Extended, Mode Select, Reassign Blocks, Receive Diagnostic Results, Send Diagnostic Results, Write and Verify, and Read Capacity. The controller has a dual-ported sector buffer that allows a 1:1 sector interleaving. For large OEM orders, the manufacturer will adapt the controller to proprietary, non-SCSI interfaces.

The drive uses the same head/disk assembly that the company's 8425 3½-in., ST506/412HP Winchester disk drive uses. The manufacturer uses additional tracks on the platters in the 8425S to install a media-defect management scheme that allocates one spare track per data cylinder. A read-only track is reserved for diagnostic information and media-degradation tracking over the life of the drive. The manufacturer also suggests a format for a track that you can use to record the drive's performance history. The 8425S costs $375 (1000).

—Steven H Leibson

Miniscribe, 1861 Lefthand Circle, Longmont, CO 80501. Phone (303) 651-6000.

Circle No 726



Featuring an integral SCSI controller, *this 3½-in. Winchester disk drive has a formatted capacity of 21.3M bytes.*

SIEMENS

Subject: innovative LED text display

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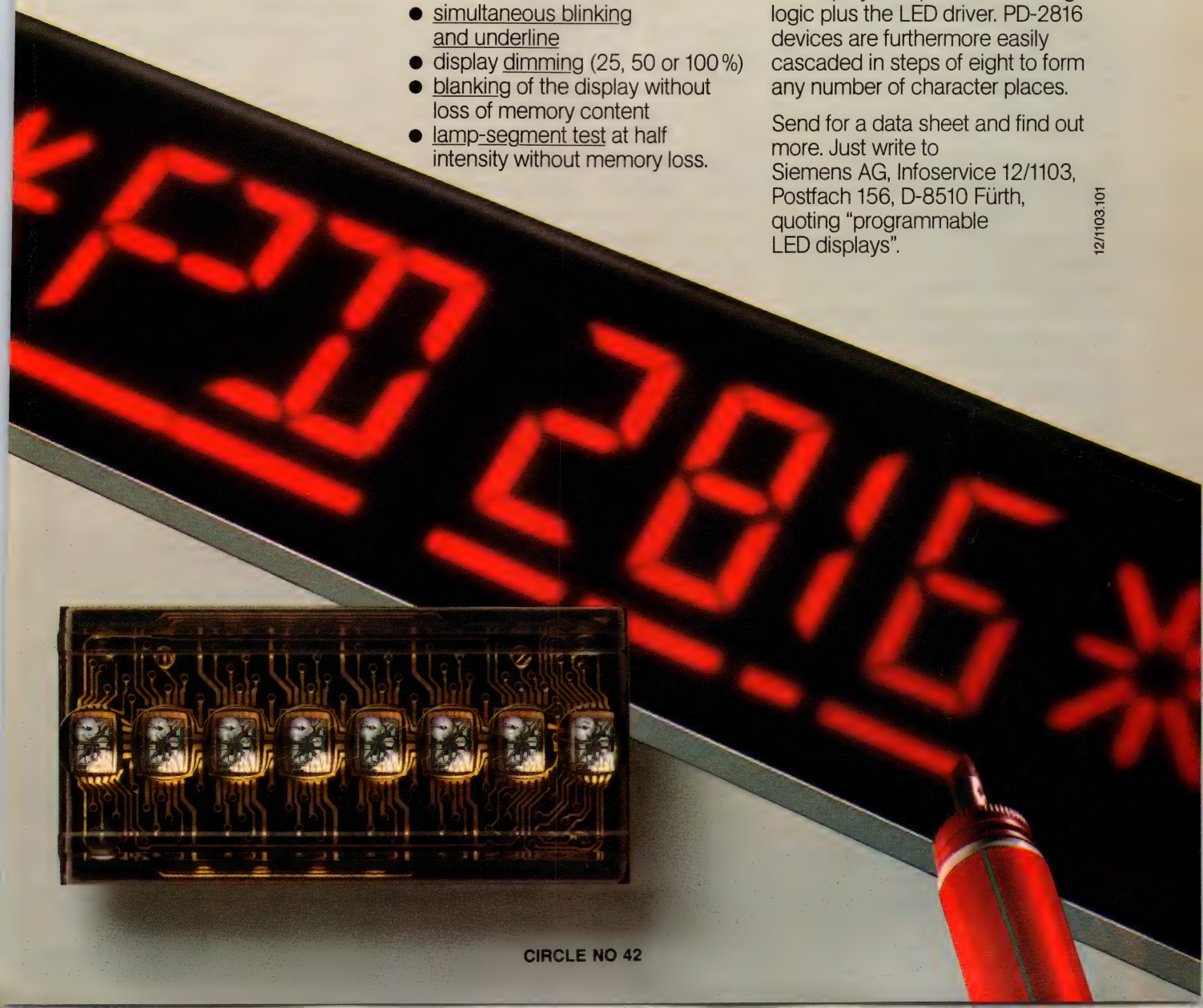
The high-intensity red characters are 4.1 mm high and magnified by lenses. The eight text positions are driven in ASCII.

The entire control logic is integrated into one CMOS circuit, containing the character-generator ROM, the display multiplexer, the timing logic plus the LED driver. PD-2816 devices are furthermore easily cascaded in steps of eight to form any number of character places.

Send for a data sheet and find out more. Just write to Siemens AG, Infoservice 12/1103, Postfach 156, D-8510 Fürth, quoting "programmable LED displays".

12/1103.101



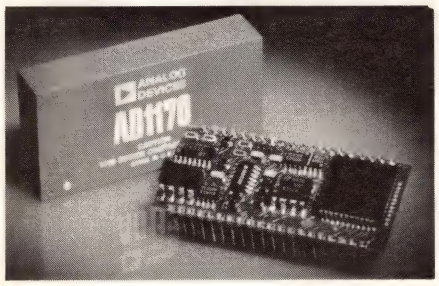
CIRCLE NO 42

Programmable integrating A/D converter yields data with 7- to 18-bit resolution

An integrating A/D converter allows you to program its integration time from 1 to 350 msec; these figures correspond to usable resolution from 7 to 18 bits, respectively. Model AD1170 (**Fig 1**) is a pc-board-based A/D converter that uses surface-mount ICs and passive components that allow the converter to fit into a 1.24×2.5×0.55-in., triple-width DIP.

The A/D converter contains a complete microcomputer-based measurement system that comprises a charge-balancing converter, a single-chip μC, and a custom CMOS controller chip. Using an 8-bit data bus, you can easily interface the AD1170—in a memory-mapped or I/O-mapped mode—to any μC-based system.

You program the AD1170's integration time by selecting one of seven preset integration periods, or by loading an arbitrary integration time over the interface bus. You can also select the data format of the output: offset binary or 2's complement. Although you could set the integration time for 22-bit resolution, usable resolution is typically limited to 18 bits because of noise errors in measurement and calibration.



Surface-mount technology keeps this A/D converter's size to a minimum: *Analog Devices houses its AD1170 A/D converter in a 40-pin triple DIP.*

Note that the AD1170 incorporates digital calibration and autozeroing, which eliminate the need for external trim potentiometers. You can recalibrate the unit at any time by applying an external reference voltage to the A/D converter's input and invoking a calibration command. You can also command the A/D converter to perform a self-calibration step (using the internal reference) whenever the converter is idle. The EEPROM shown in **Fig 1** stores the calibration data.

The AD1170's conversion throughput is, of course, a function of the integration time. For integration times of 1, 16.667, and 100 msec, for example, the respective conversion rates are 250, 50, and 9 conversions/sec. Differential nonlinearity is an inverse function of conversion time. For conversion times ranging from 1 to 300 msec, the differential nonlinearity varies from ±0.001% to ±0.0003% of full-scale range.

The AD1170 also offers ±5-ppm/°C gain stability, 86-dB power-supply rejection ratio, and 100-MΩ input impedance. Integral nonlinearity is ±10 ppm of full-scale range. Power-supply currents are typically 20 mA from the ±15V supplies and 170 mA from the 5V supply. $98 (100)—***Bill Travis***

Analog Devices Inc, Box 280, Norwood, MA 02062. Phone (617) 329-4700.

Circle No 728

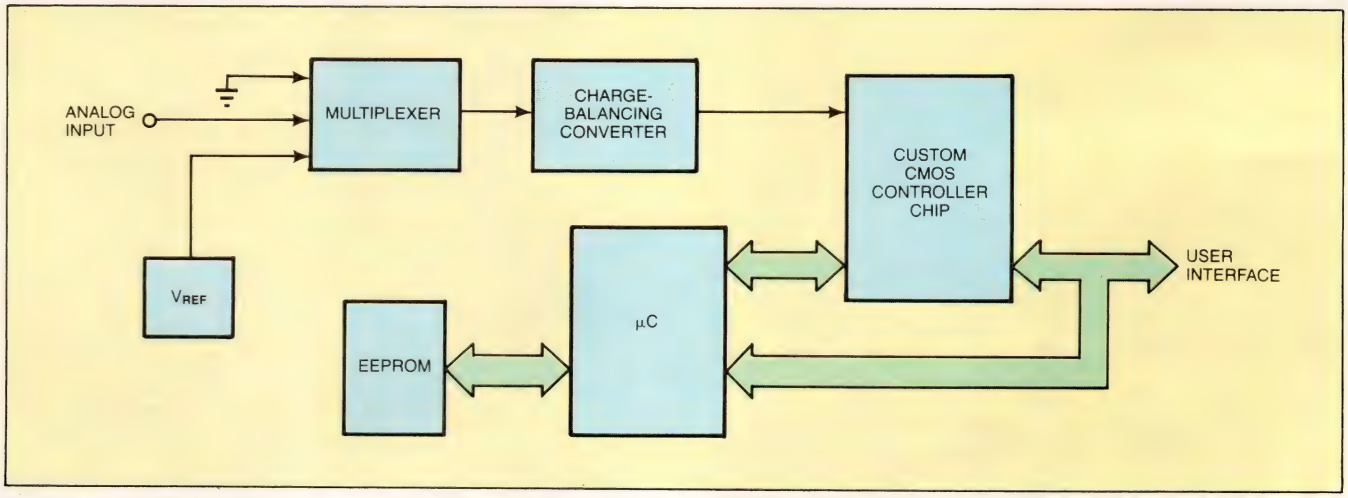


Fig 1—A veritable analog-processing instrument in a DIP, *the AD1170 is an intelligent A/D converter. You can program its integration time to obtain any effective resolution from 7 to 18 bits, and you can command the converter to perform autozeroing and calibration functions. The A/D converter's interface to a μP bus lets you use simple commands to program the converter's functions.*

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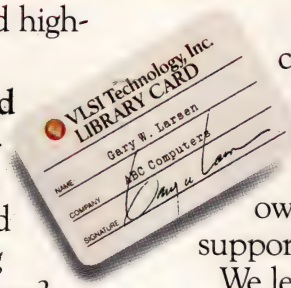

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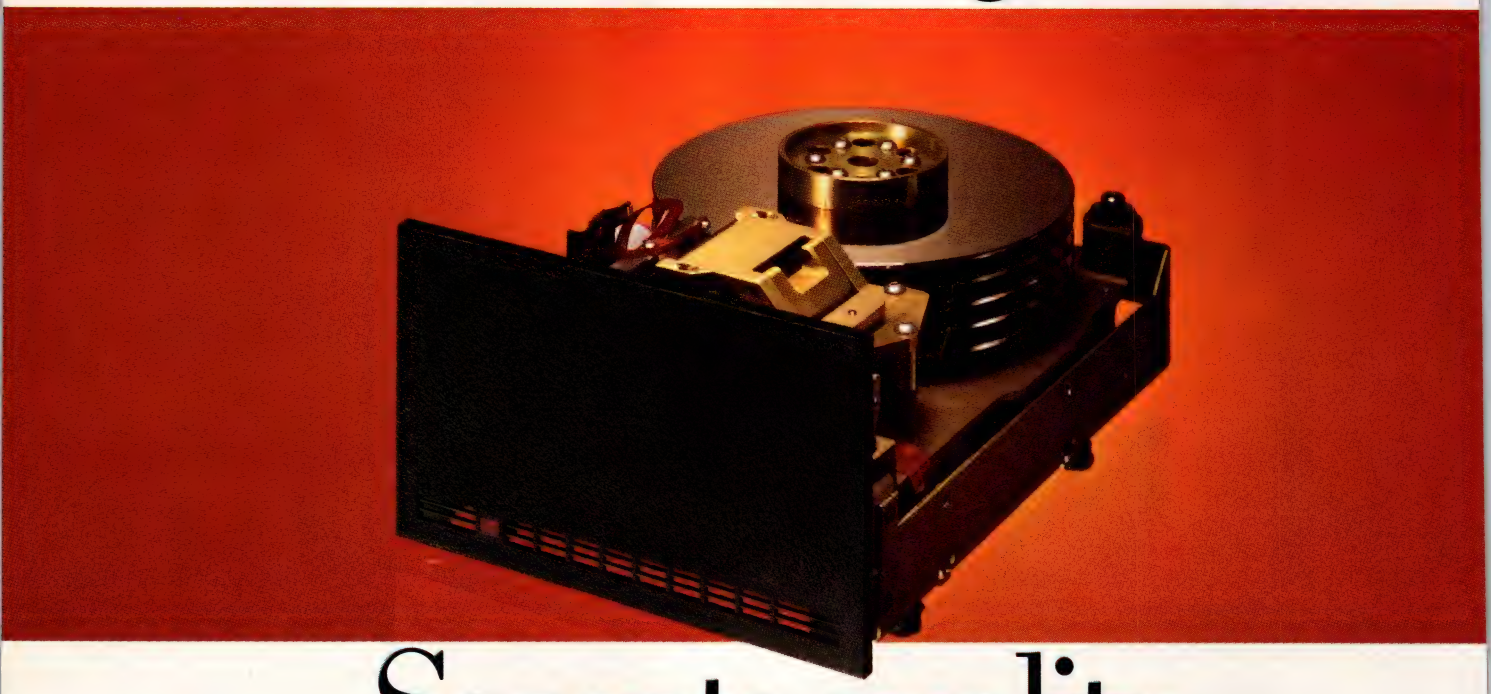

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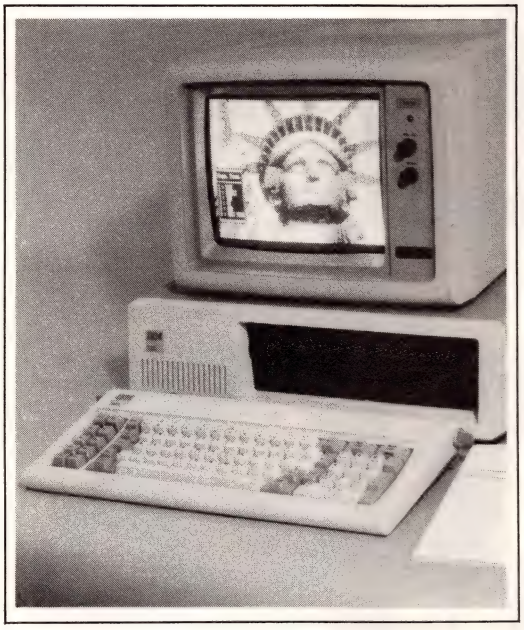
CIRCLE NO 94

READERS' CHOICE

Of all the new products covered in EDN's **May 29, 1986,** issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, or refer to the indicated pages in our **May 29, 1986,** issue.

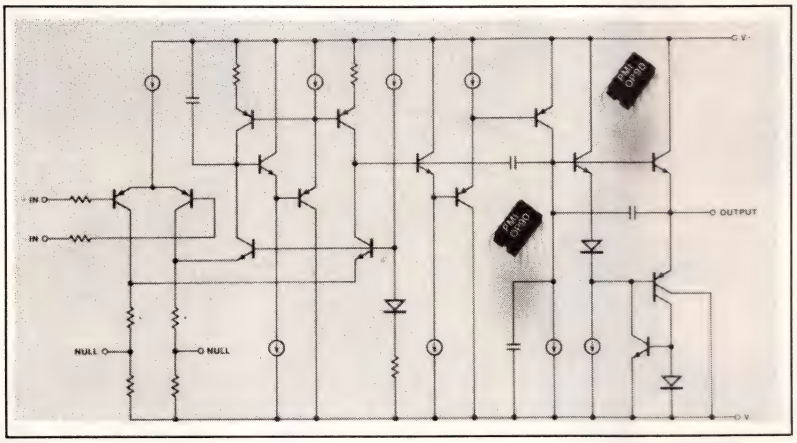
▶VIDEO DIGITIZER

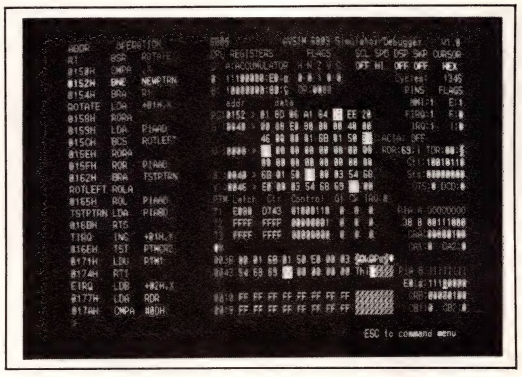
Image Ace II digitizes video images from cameras, TV tuners, and video recorders and displays them directly on IBM PC screens (pg 244).
Lodge Electronics. Circle No 605



▲PC-BASED CAE/CAD

The EE Designer package consists of a schematic-capture, logic-simulator, and pc-board-layout program (pg 248).
Visionics Corp. Circle No 602



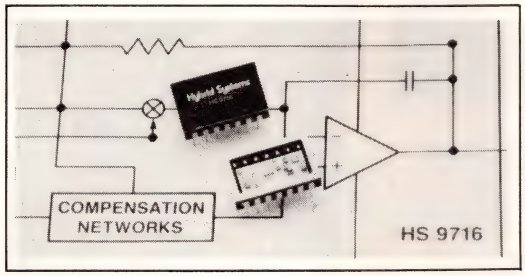


▲6809 SIMULATOR

The AVSIM09 runs on an IBM PC and interpretively executes 6809 object code under control of a full-screen symbolic debugger (pg 252).
Avocet Systems Inc. Circle No 606

▲OPERATIONAL AMPLIFIER

The bipolar, micropower OP-90 draws only 20-μA max supply current and operates from single or dual supplies to overcome low-current-device shortcomings (pg 84).
Precision Monolithics Inc. Circle No 604



▲HYBRID S/H AMPLIFIERS

HS9716 and HS9714 use dielectric-absorption compensation, making them suitable for use in 16- and 14-bit analog data-acquisition systems, respectively (pg 91).
Hybrid Systems Corp. Circle No 601

MULTIBUS MEMORY BOARD

The DS-541M accommodates machine-vision algorithms and holds four 512×512-pixel images (pg 79).
Recognition Technology Inc. Circle No 603

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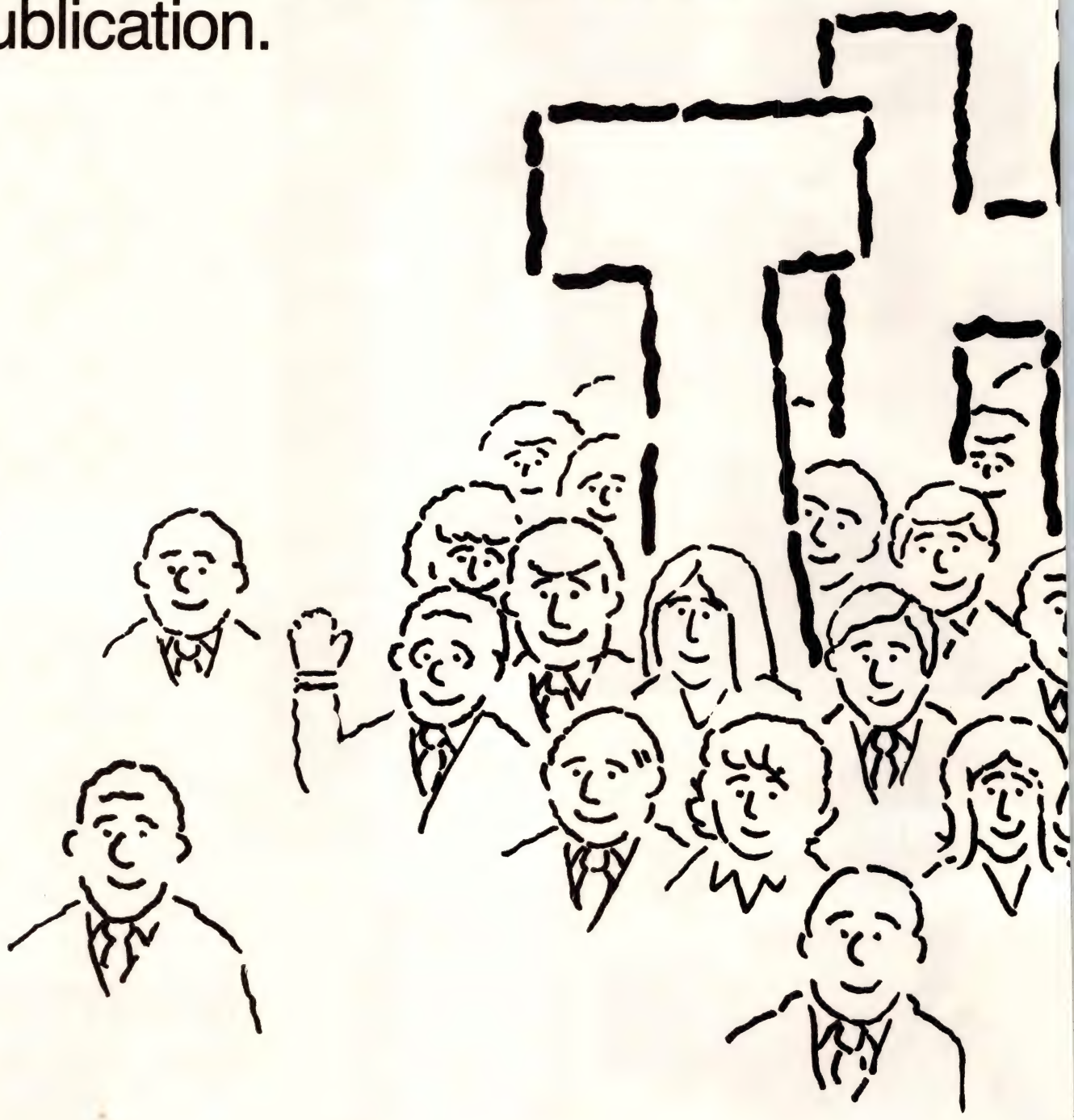

From the staff of EDN

LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	0	0	67	33	0	0	10.7	8.0
Pot-Core	0	25	50	25	0	0	8.5	10.0
Laminate (power)	20	20	50	10	0	0	6.0	8.5
CONNECTORS								
Military panel	11	0	34	22	22	11	15.4	8.0
Flat/Cable	14	43	43	0	0	0	4.3	5.0
Multipin circular	0	25	59	8	8	0	8.7	8.7
PC	0	57	43	0	0	0	4.6	6.0
RF/Coaxial	9	37	36	9	9	0	7.5	10.5
Socket	18	27	55	0	0	0	4.9	6.9
Terminal blocks	15	31	54	0	0	0	4.9	4.7
Edge card	20	20	60	0	0	0	5.2	7.4
Subminiature	0	20	40	20	20	0	12.0	6.0
Rack & panel	0	0	100	0	0	0	8.0	12.0
Power	14	29	43	14	0	0	6.3	8.4
PRINTED CIRCUIT BOARDS								
Single-sided	0	50	43	7	0	0	5.6	3.8
Double-sided	0	45	55	0	0	0	5.3	14.2
Multilayer	0	33	67	0	0	0	6.0	7.0
Prototype	0	75	17	0	0	8	5.4	2.4
RESISTORS								
Carbon film	47	20	33	0	0	0	3.1	4.3
Carbon composition	28	36	29	7	0	0	4.1	6.0
Metal film	27	20	53	0	0	0	4.7	5.1
Metal oxide	0	29	71	0	0	0	6.3	7.0
Wirewound	17	33	33	17	0	0	6.0	6.8
Potentiometers	13	20	40	27	0	0	7.9	8.4
Networks	30	30	30	10	0	0	4.6	6.4
FUSES	55	18	27	0	0	0	2.5	3.5
SWITCHES								
Pushbutton	33	25	42	0	0	0	3.8	6.3
Rotary	0	50	50	0	0	0	5.0	8.3
Rocker	10	40	40	10	0	0	5.6	8.3
Thumbwheel	0	25	75	0	0	0	6.5	8.4
Snap action	20	40	40	0	0	0	4.0	8.5
Momentary	0	25	75	0	0	0	6.5	6.0
Dual in-line	0	50	50	0	0	0	5.0	8.5
WIRE AND CABLE								
Coaxial	25	67	8	0	0	0	2.0	4.3
Flat ribbon	14	57	29	0	0	0	3.4	2.7
Multiconductor	14	57	14	15	0	0	4.6	4.5
Hookup	38	50	12	0	0	0	2.0	1.9
Wire wrap	29	43	28	0	0	0	3.1	2.9
Power cords	18	41	41	0	0	0	4.1	5.6
Other	0	0	100	0	0	0	8.0	4.8
POWER SUPPLIES								
Switching	0	0	100	0	0	0	8.0	8.4
Linear	0	57	43	0	0	0	4.6	8.3
CIRCUIT BREAKERS	10	30	60	0	0	0	5.4	8.3
HEAT SINKS	29	47	12	12	0	0	3.8	4.8

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
General purpose	17	50	25	8	0	0	4.3	8.2
PC board	0	33	33	34	0	0	8.7	10.6
Dry reed	0	0	100	0	0	0	8.0	8.7
Mercury	0	0	100	0	0	0	8.0	8.7
Solid state	20	40	40	0	0	0	4.0	8.6
DISCRETE SEMICONDUCTORS								
Diode	23	24	35	12	6	0	6.7	5.9
Zener	14	29	36	21	0	0	6.9	5.9
Thyristor	0	0	40	60	0	0	12.8	7.6
Small signal transistor	0	40	30	30	0	0	8.0	6.3
FET, MOS	0	20	40	40	0	0	10.0	9.3
Power, bipolar	0	0	50	25	25	0	14.5	6.7
INTEGRATED CIRCUITS, DIGITAL								
CMOS	0	40	20	40	0	0	8.8	9.3
TTL	14	14	43	29	0	0	8.3	8.3
LS	22	11	44	22	0	0	7.3	9.5
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	0	0	67	33	0	0	10.7	12.0
OP amplifier	13	25	38	12	12	0	8.8	11.4
Voltage regulator	9	37	27	9	18	0	9.1	9.8
MEMORY CIRCUITS								
RAM 16k	0	0	75	25	0	0	10.0	10.3
RAM 64k	0	0	75	25	0	0	10.0	10.0
RAM 256k	0	0	67	0	33	0	14.0	8.3
ROM/PROM	0	0	67	33	0	0	10.7	11.0
EPROM	0	25	38	37	0	0	9.5	9.6
EEPROM	0	0	67	33	0	0	10.7	9.1
DISPLAYS								
Panel meters	13	25	37	25	0	0	7.5	10.0
Fluorescent	20	20	60	0	0	0	5.2	12.0
Incandescent	17	33	50	0	0	0	4.7	8.7
LED	0	36	55	9	0	0	6.5	6.9
Liquid crystal	0	25	63	12	0	0	7.5	9.7
MICROPROCESSOR ICs								
8-bit	0	25	50	25	0	0	8.5	10.3
16-bit	0	20	60	0	0	0	10.4	7.1
FUNCTION PACKAGES								
Amplifier	0	0	50	50	0	0	12.0	10.7
Converter, analog to digital	0	25	50	25	0	0	8.5	10.6
Converter, digital to analog	0	33	33	34	0	0	8.7	11.0
LINE FILTERS	0	75	25	0	0	0	3.5	5.6
CAPACITORS								
Ceramic	8	38	46	8	0	0	5.7	6.0
Ceramic monolithic	0	25	63	12	0	0	7.5	6.4
Ceramic disc	0	55	27	18	0	0	6.2	5.8
Film	17	42	33	8	0	0	4.8	6.4
Electrolytic	14	29	43	14	0	0	6.3	6.5
Tantalum	8	31	46	15	0	0	6.8	7.1
INDUCTORS	0	33	33	34	0	0	8.7	6.0

Source: *Electronics Purchasing* magazine's survey of buyers

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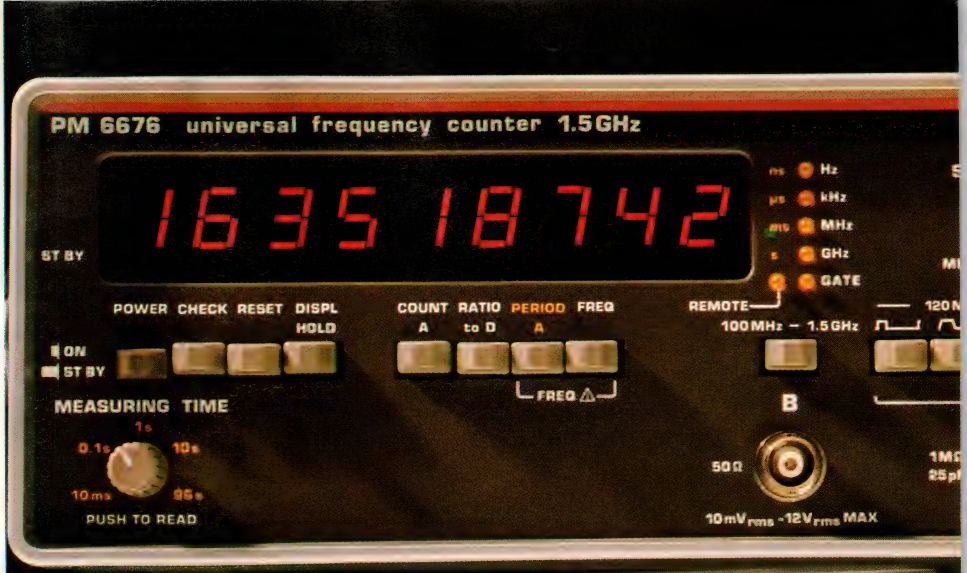

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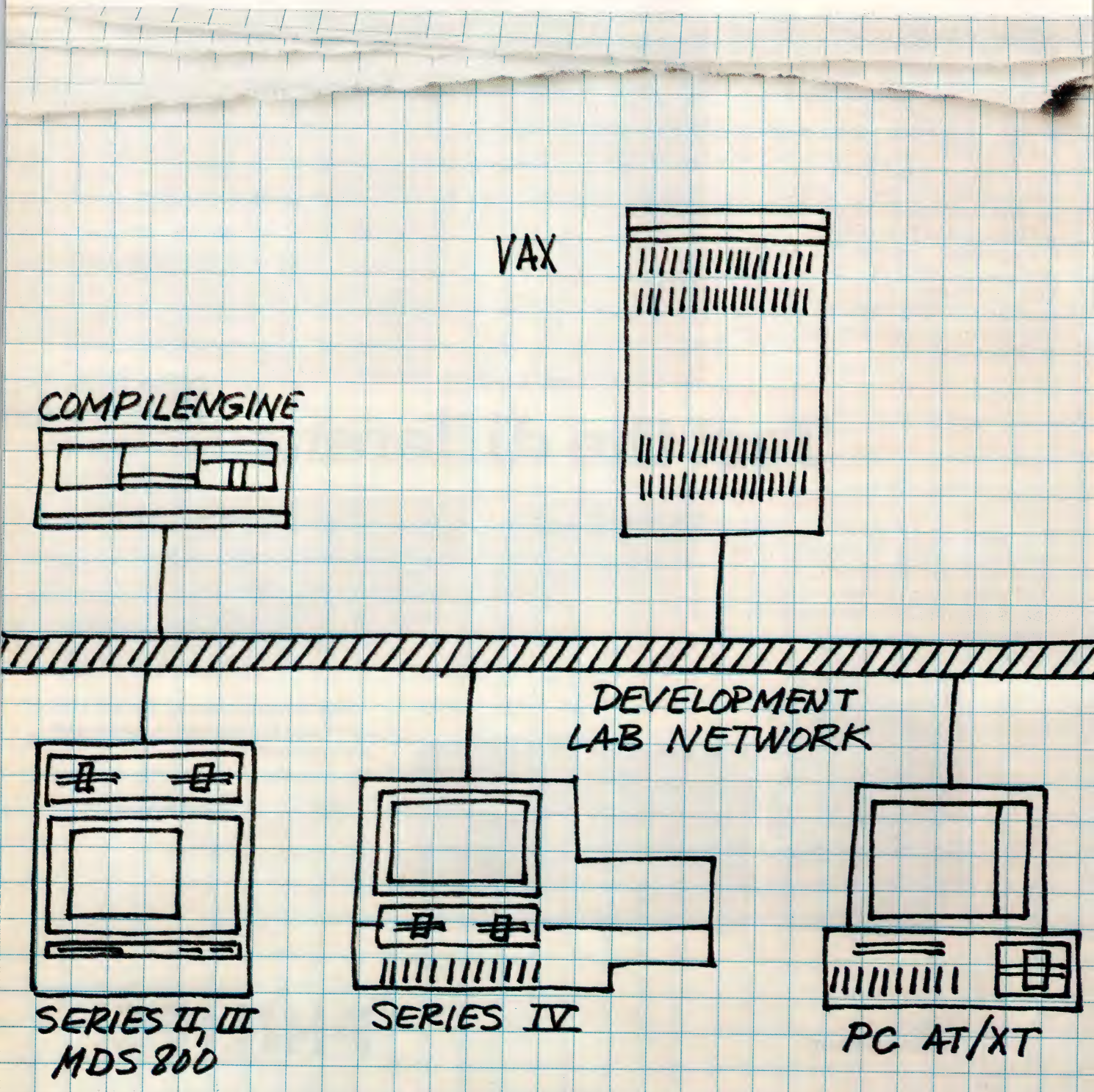

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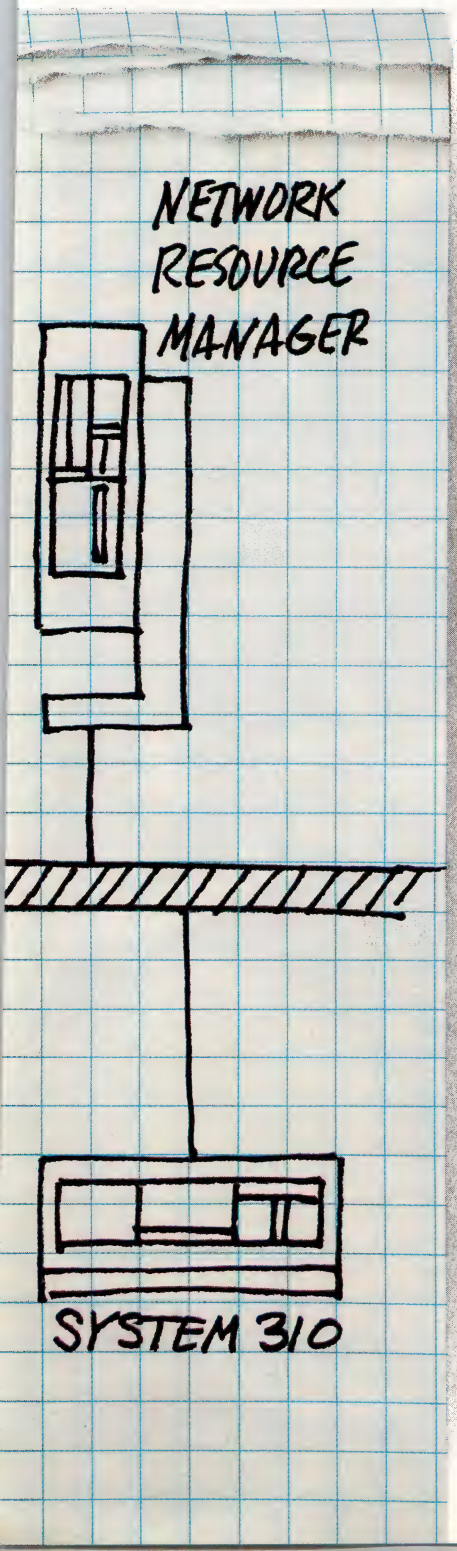

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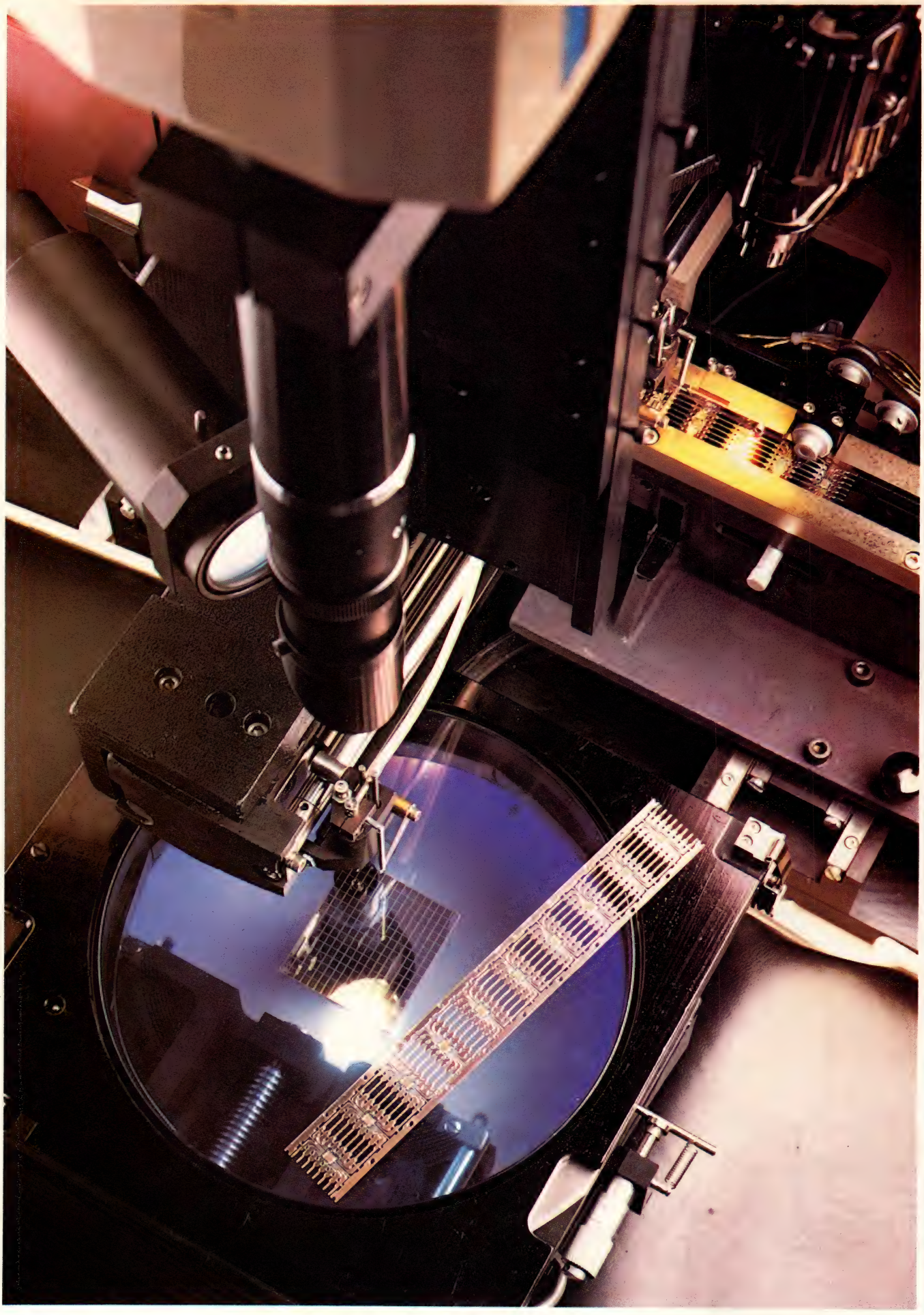


Resistor chips, networks, and discrete resistors

Tarlton Fleming, *Associate Editor*

Electronic packaging's evolution toward surface-mount components is forcing a transformation of the US resistor industry: New product types; new methods of assembly and manufacture; and the divestment, acquisition, and merging of companies are giving the industry a new look.

Because resistors have exhibited so little change from year to year, engineers tend to regard the resistive-products industry as low-tech and static (ie, "mature"). This view is partially true of the commodity leaded-resistor products; no dramatic changes in their resistive materials appear imminent. Resistor packaging, however, is another matter. The relentless shrinking and repackaging of the devices has resulted in an evolution from conventional products to surface-mount chips and networks, which require expensive automated-assembly equipment.

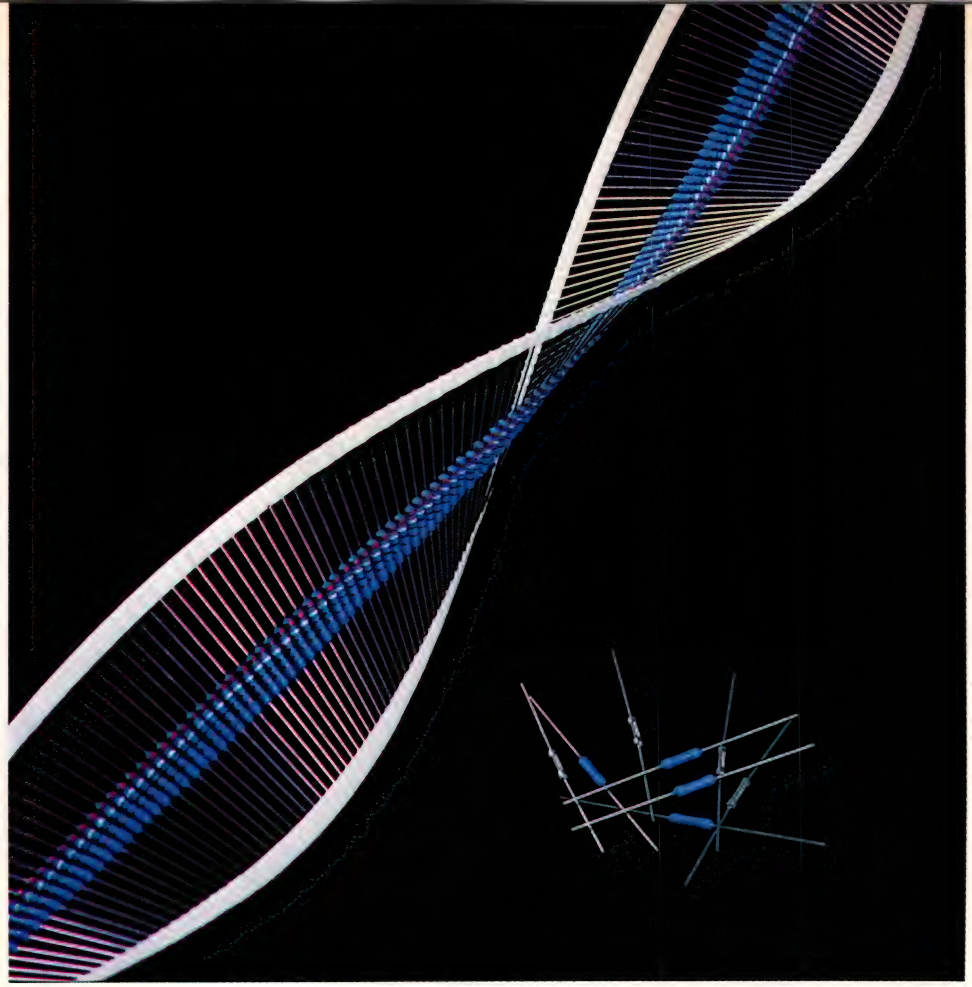
Before you take your next excursion into the resistor market, note a few changes in the players. Resistor makers have had to restructure their product lines while coping with a recent cycle of boom (1984) and bust (1985). In addition, offshore competition has led to price erosion and declining profits, making the manufacturer's job a tough one indeed. Not all domestic manufacturers have made it; the result is a new array of companies offering a new array of products.

Company realignments in the past year include the merging of Mepco/Electra and Centralab (both owned by North American Philips). The new Mepco/Centralab headquarters is in West Palm Beach, FL. Vishay Intertechnology and a British company, Mezzanine Capital Corp Ltd, have purchased Dale Electronics. The Dale and Vishay operations will remain separate, however. Ultronix has purchased the Oak Industries' Techno Components Division, which makes military-approved thick-film networks and trimmers.

TRW Inc had proposed the sale of certain mature product lines within its Resistive Products Division. Managers of that division, though, persuaded the corporate planners that the organization should remain intact. Consequently, TRW will divest the entire division by the end of the year, according to Dick Paden, director of sales and marketing.

The prime cause of the changes in product lines has been the struggle to produce resistor products that occupy less space on a pc board than did their predecessors. Size was less of an issue when carbon-composition resistors were introduced, for example, so a typical unit was physically large enough to support a power rating of ½W. Later, suppliers were able to reduce the size of their resistors when customers began to demand ¼W resistors of all types. In time, the lower supply voltages accompanying the process of miniaturization in elec-

Fixed resistors *adapt to today's manufacturing and packaging requirements. (Photo Courtesy Dale Electronics Inc)*



These wirewound resistors feature a flame-resistant coating *and offer resistance values from 0.10 to 2400Ω in 1, 2, or 3W sizes. The selection, TRW Electronics Group's SPP Series, includes various combinations of voltage-surge capabilities and fuse characteristics.*

tronics allowed use of the ⅛W resistors that are common today. Many of these resistors can be even smaller, because they carry only microamperes of current.

Noteworthy developments in the fixed-resistor industry include the elimination of leads from discrete resistors to yield small, surface-mountable flat-chip devices and MELFs (devices that employ metal-electrode face bonding); the consolidation of discrete resistors into surface-mountable networks-on-a-chip; a controversy as to what package style for automatic placement should become standard for these networks; and refinements in the performance of various special-purpose resistors.

Surface-mount parts will dominate

Manufacturers agree that the bulk of resistor business will eventually consist of surface-mount, single-resistor or network chips, but the cost of new assembly equipment will slow this changeover by a number of years. Meanwhile, some manufacturers are offering very small leaded resistors (⅕W, ⅒W, 1/20W), not so much to give designers a selection of power ratings as to give them an interim solution to the problem of component density—ie, of packing as many components as possible on a board.

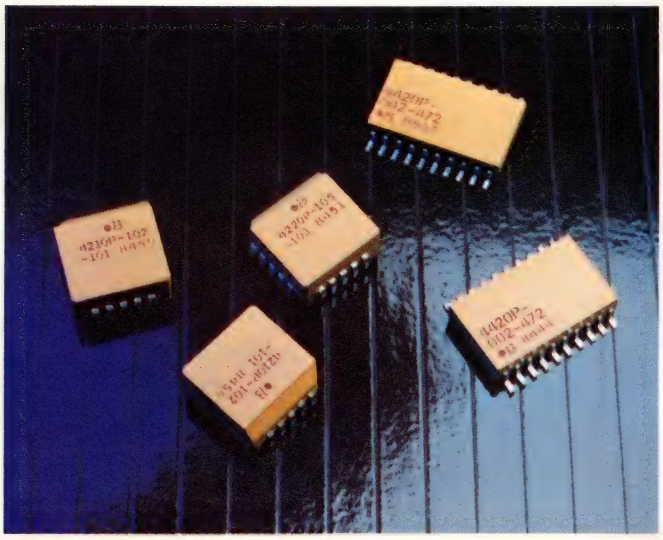
Circuit density certainly improves with the use of small resistor chips, and reliability improves as well, because lead frames and bonding wires are eliminated. Resistors in chip form were developed in Japan for use in consumer electronics products, and their use continues to grow in the wake of advancing surface-mount technology, ie, only the manufacturers that own or have access to the equipment for automatic placement, soldering, and testing can use these chips in quantity. Consequently, resistor chips are moving into computers, disk drives, and other products.

Resistor chips—the simplest components

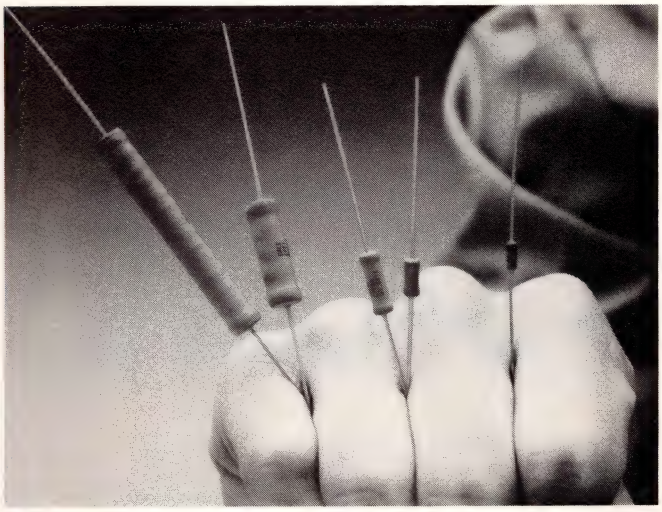
Most chip-resistor products use thick-film material for the resistive element. Thick film is a paste mixture of metal-oxide and glass or ceramic particles, screened onto a ceramic substrate and fired at high temperature. The remaining chip-fabrication steps are particular to each manufacturer.

Allen-Bradley, for example, prints and fires the termination pads and then the resistive element and then adds a glass-passivation layer to protect the resistor. The company laser-trims the resistor to the desired value, adds a final epoxy coating to the body of the resistor, and then breaks the substrate into chips. Each chip receives a metal wrap-around termination on each end that allows you to mount the resistor with either side up. Finally, the company applies a solder-resistant nickel coating over the end termination (to block solder from the resistive element during assembly) and adds a solderable coating over the outer portion of nickel. The resulting product, type BC, measures 120×60 mils. It specs 10Ω to 2.2 MΩ resistance, a 1% or 5% tolerance, a ±100- or ±200-ppm/°C temperature coefficient, and a ⅛W power rating. Prices for the type BC resistors

The relentless shrinking and repackaging of resistors has resulted in an evolution from conventional products to surface-mount chips and networks.



***Among the contending surface-mount package styles** are the small-outline type with gull-wing leads (right) and the plastic chip-carrier type with J-shaped leads (left). These parts are from Bourns Inc.*



***These flameproof, metal-film resistors operate at temperatures to 230°C.** The CPF resistors from Dale Electronics provide resistance values from 5 to 150 kΩ, power ratings to 10W, tolerances as low as ±0.5%, and a TCR of ±100 ppm/°C.*

range from $12.50 to $19.50 (per 1000 in 25,000-piece lots).

The 120×60-mil chip resistor, called the 1206 type, currently dominates chip applications in the US. In Japan, more and more applications are demanding the smaller 80×50-mil (2×1.25-mm) 805-type chip resistor. Japanese manufacturers are also producing a part that's smaller still, the 1.6×0.8-mm 1608 chip.

Most of these chips use thick film. In contrast, the BLU-chip Series from RCD Components is based on nickel-chromium (NiCr) thin film. The series includes a ⅛W 1206 device as well as larger 4.2×3-mm (¼W) and 5.6×4.1-mm (½W) chips. Prices range from $0.10 to $0.25 (10,000). Another company, Dale Electronics, has a thin-film 1206 part under development.

Most 1206 chips spec a ⅛W power rating. RCD Components, however, has fabricated a ¼W 1206 by using a thicker cermet film, thicker silver terminations, and extra-high-purity alumina for good thermal conduction. The ¼W 1206 part costs $0.01 to $0.02 (10,000). Kyocera, too, offers a ¼W 1206, the CR32 Series, which is based on the widely used ruthenium-oxide cermet film. These parts cost $0.05 to $1 (10,000).

MELF—a resistor that forgot its leads

Another type of surface-mount resistor is the MELF. A MELF is a small cylindrical component with metal caps on each end, suitable for attachment to a pc board by reflow-soldering techniques. Although less expensive than equivalent flat chips, MELFs require different automatic-placement equipment. Some say they're harder to handle than chips (they roll around). Designers in the US generally prefer flat-chip resistors to MELFs. In Japan, the use of MELFs is supported by a limited number of large-volume customers, who already have the special automatic-placement equipment in place and are therefore in a position to take advantage of MELFs' lower prices.

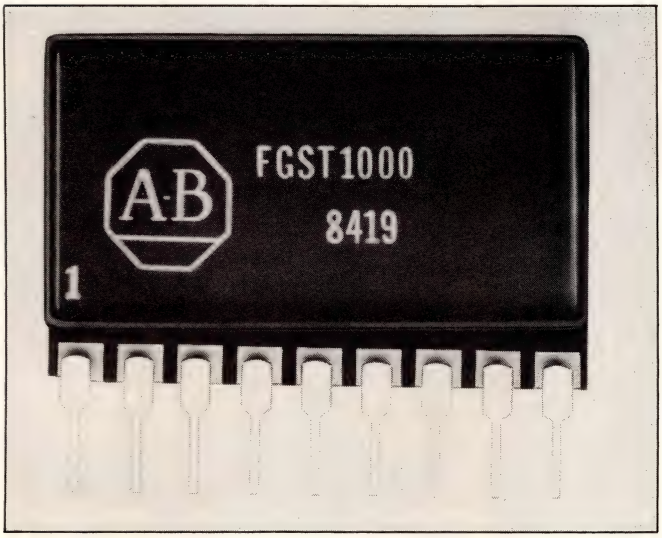
You can obtain MELFs from Rohm Corp and RCD Components. The latter offers thick- and thin-film MELFs, and it's in the process of developing power MELFs with ratings to 5W. TRW even offers a wirewound MELF device, the AS-SM Series, for approximately $0.80 (1000). The company has thoughtfully flattened the end caps of these devices to keep them from rolling.

Surface-mount chips and networks

Single-resistor chips and MELFs seem destined for different areas of application than resistor networks. Networks, for example, are an obvious choice for digital systems in which pull-up, pull-down, or bus-termination resistors usually occur in multiples of eight. Resistor chips and MELFs, on the other hand, are appropriate for analog circuits that include a mixture of sizes and ohmic values. Today, though, a given system may employ either chips or networks according to the exigencies of price and convenience.

You can solder single-resistor chips or small network chips directly to a board or substrate, but the larger

The prime cause of the changes in product lines has been the struggle to produce resistor products that occupy less space on a pc board.



This thin-film, precision divider network *from Allen-Bradley contains six resistors with values ranging from 100Ω to 9 MΩ. It provides 6-decade attenuation for voltages as high as 1 kV.*

These 1206 thick-film resistor chips *from Corning Electronics' Series CR measure 120×60 mils and spec 10Ω to 1 MΩ resistance values, ±1% tolerance, and ±100-ppm/°C TCR.*

network chips require flexible leads (ie, a package) between the chip and board. Without the package, differential thermal expansion may rupture the electrical connections as the temperature changes. Because surface-mount assembly equipment is both expensive and package-specific, many OEMs have postponed investment in these machines until one of the network packages currently available becomes at least a de facto standard.

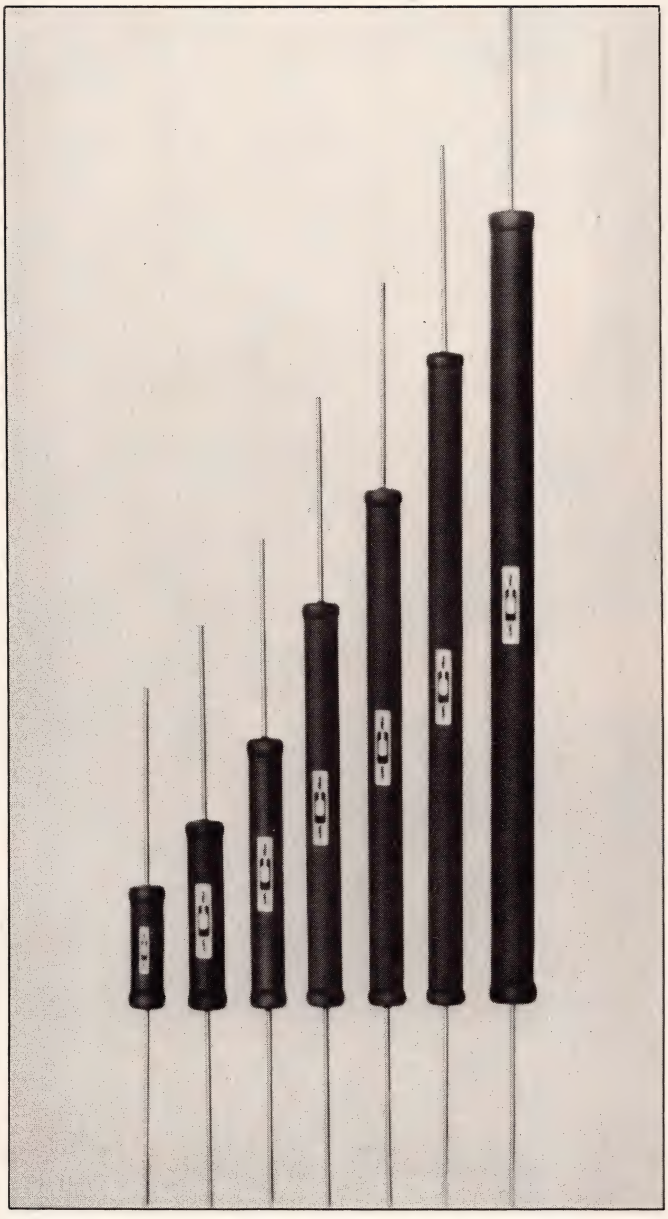
In many large companies, the automatic-placement equipment for the assembly of surface-mount IC components has been in place for some time. Naturally, the first passive-network packages were built to be compatible with this existing equipment; these JEDEC-standard packages include the leaded chip-carrier type and the EIA-approved small-outline (SO) types with either J-shaped or gull-wing leads. J-leads fit easily into sockets, and they don't increase a package's footprint, because the leads curve under the package. Gull-wing leads turn out and take up more space, but they also make possible the visual inspections necessary in military systems. Some nonmilitary manufacturers as well will require such inspections until they gain confidence in the reliability of the new packages.

Allen-Bradley is one company that believes that the J-lead SO package will become the preferred style for surface mounting and automated assembly, and the company plans to offer only that type, the Series SOJ. Bourns Inc's J-lead molded chip carrier, the 4200P Series, and its gull-wing molded SO package, the 4400P Series, will be available later this year. Beckman Industrial Corp offers the SORD (small-outline resistive device) in a 14- or 16-lead gull-wing SO package and in a 10- or 20-lead chip-carrier configuration. The SO parts cost $0.60 to $0.65, and the chip-carrier devices cost $0.75 to $0.85 (1000). Dale Electronics supplies the 14- or 16-lead SOMC (small-outline micro circuit), which has gull-wing leads. The SMOC-1601 costs $0.59 (1000). Sprague Electric's Series 800 SORN (small-outline resistor network) is a gull-wing SO package that comes in 154- or 295-mil widths. Initial pricing for these parts, which will be available in production quantities this fall, is approximately $0.75 (1000).

STRIPs, SIPs, and ZIPs

Sprague is developing a surface-mount package for networks that offers a smaller footprint than the SO type. Samples of the STRIP (stand-up resistor in-line package) are scheduled for introduction by the end of the year, according to marketing manager John R Webb. The new package supports the substrate at a right angle to the board (as does a single-in-line package, or SIP) but has two narrowly spaced rows of solder-bump terminations (as does a ZIP, ie, the SIP-like IC package whose pins are staggered in a zig-zag pattern). The STRIP, however, provides nonstaggered terminations on 50-mil centers in each row, yielding twice as many connections (16 to 24) as a ZIP of similar length.

Substrates with solder bumps are another package



These thick-film, high-voltage resistors *from Caddock Electronics, type TG, combine a 25-ppm/°C TCR with operating voltages as high as 30 kV.*

option for surface-mount resistor networks. Because solder-bump connections are susceptible to mechanical stress, you must carefully evaluate their application to your design. The factors to consider, according to marketing manager Jack Polakowski of Allen-Bradley, are the type of pc board you intend to use, whether the board will be flexed, and the anticipated excursions in ambient temperature.

Allen-Bradley's Model 800 SARA (surface-attachable resistor array) consists of thick-film standard or custom networks on a ceramic substrate with solder bump terminations. Although the larger versions of the chip are subject to thermal-expansion problems (the largest has the footprint of a 16-pin DIP), you can mount them without difficulty on another ceramic substrate or on a small G10- or FR4-epoxy pc board. Larger boards may bend enough to break the solder-bump connections. However, the heavy use of these products in automotive electronics illustrates that they are reliable when properly applied. SARAs range in price from \$0.25 to \$0.50 (2500).

TRW's Model 7900/7909 is another resistor network with solder-bump terminations. Comprising either 19 resistors tied to a common connection or 10 isolated resistors, these networks are made of self-passivating tantalum-nitride (Ta_2N) thin film. Their chip-carrier configuration meets the JEDEC standard for type C packages (0.350 in^2, with five terminals on a side). Furthermore, this package is compatible with automatic handlers that use vacuum suction to pick up parts from the top. The devices cost \$7 to \$18 (1000).

Thin film for stability and precision

Single-resistor and network chips of the thin-film variety constitute only 1% of the market, but they suit applications that require tighter tolerances and greater stability than thick-film devices can handle. NiCr is the most widely used thin-film material, but Ta_2N offers some useful attributes. Although the two materials are comparable in performance, NiCr currently has the edge over Ta_2N in resistance tolerance and in temperature coefficient of resistance (TCR). Ta_2N, on the other hand, offers a wider range because its resistivity is higher (approximately 1000Ω/sq vs 250Ω/sq). More important, the inherent passivation properties of nitride eliminate a manufacturing step—the addition of glass passivation that's required with NiCr.

Semi-Films specializes in the manufacture of Ta_2N thin-film products that are suitable for use in hybrid circuits. The company's standard products spec TCRs as low as ±10 ppm/°C and tolerances as tight as ±0.1%. Top-contact types require a die attach plus two wire bonds, and in back-contact types the die attach provides one connection and one wire bond provides the other. The flip-chip style attaches like a surface-mount component, using solder bumps. The company does not yet offer surface-mount components for pc applications.

Ultronix Inc (a subsidiary of Sfernice, Nice, France) offers devices fabricated from a "third-generation"

Text continued on pg 148

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Milwaukee, WI 53204
(414) 289-9700
Circle No 676

Beckman Industrial Corp
Electronic Technologies Div
4141 Palm St
Fullerton, CA 92635
(714) 447-2300
Circle No 677

Bourns Inc
1200 Columbia Ave
Riverside, CA 92507
(714) 781-5050
Circle No 678

Caddock Electronics Inc
1717 Chicago Ave
Riverside, CA 92507
(714) 788-1700
Circle No 679

California Micro Devices
215 Topaz St
Milpitas, CA 95035
(408) 263-3214
Circle No 680

Clarostat Mfg Co Inc
1 Washington St
Dover, NH 03820
(603) 742-1120
Circle No 681

Corning Electronics
Corning Glass Works
Houghton Park, A-2
Corning, NY 14831
(607) 974-8725
Circle No 682

CTS Corp
905 N West Blvd
Elkhart, IN 46514
(219) 293-7511
Circle No 683

Dale Electronics Inc
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Columbus, NE 68601
(402) 564-3131
Circle No 684

Electro Films Inc
111 Gilbane St
Warwick, RI 02886
(401) 738-9150
Circle No 685

Hamilton Hall Resistor Corp
227 N Water St
Milwaukee, WI 53202
(414) 273-6460
Circle No 686

Huntington Electric Inc
Box 366-A
Huntington, IN 46750
(219) 356-0778
Circle No 687

Hybrid Systems Corp
22 Linnell Circle
Billerica, MA 01821
(617) 667-8700
Circle No 688

Hycomp Inc
75 Union Ave
Sudbury, MA 01776
(617) 443-4631
Circle No 689

International Manufacturing Services Inc
50 Schoolhouse Ln
Portsmouth, RI 02871
(401) 683-9700
Circle No 690

Interohm International
International Components Corp
105 Maxess Rd
Melville, NY 11747
(516) 293-1500
Circle No 691

Jaro Components Inc
5549 Powerline Rd
Fort Lauderdale, FL 33309
(800) 327-5551
Circle No 692

Julie Research Labs Inc
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New York, NY 10023
(212) 245-2727
Circle No 693

Kamaya Inc
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Fort Wayne, IN 46818
(219) 489-1533
Circle No 694

Kelvin Corp
14724 Ventura Blvd
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(818) 990-1192
Circle No 695

Kyocera International Inc
Electronic Components Group
11425 Sorrento Valley Rd
San Diego, CA 92121
(619) 454-1800
Circle No 696

K-Tronics Inc
Box 893
Lincolnton, NC 28093
(704) 735-8237
Circle No 697

LTI Inc
6445 N Hamlin
Lincolnwood, IL 60645
(312) 679-7500
Circle No 698

Mepco/Centralab
5900 Australian Ave
West Palm Beach, FL 33407
(305) 842-3201
Circle No 699

Micro-Ohm Corp
4900 Santa Anita Dr
El Monte, CA 91731
(818) 442-3310
Circle No 700

Mills Resistor Co Inc
3840 Catalina
Los Alamitos, CA 90720
(213) 598-2454
Circle No 701

Milwaukee Resistor Corp
700 W Virginia St
Milwaukee, WI 53204
(414) 271-9900
Circle No 702

Mini-Systems Inc
20 David Rd
North Attleboro, MA 02761
(617) 695-0203
Circle No 703

NIC Components Corp
238 Route 109
Farmingdale, NY 11735
(516) 694-0060
Circle No 704

Ohmite Manufacturing Co
3601 W Howard St
Skokie, IL 60076
(312) 675-2600
Circle No 705

Box continued on pg 148

Called the 1206 type, the 120×60-mil chip resistor currently dominates chip applications in the US.

Manufacturers . . .

Box continued from pg 147

Ohmtek Inc
2160 Liberty Dr
Niagara Falls, NY 14304
(716) 283-4025
Circle No 706

Paccom Electronics
3928 148th St NE
Redmond, WA 98052
(206) 883-9200
Circle No 707

Pacific Resistor Co
18300 Oxnard St
Tarzana, CA 91356
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Circle No 708

Precision Resistive Products Inc
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Mediapolis, IA 52637
(319) 394-9131
Circle No 709

Precision Resistor Co Inc
10601 75th St North
Largo, FL 33543
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Circle No 710

RCD Components Inc
330 Bedford St
Manchester, NH 03101
(603) 669-0054
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Rohm Corp
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Irvine, CA 92713
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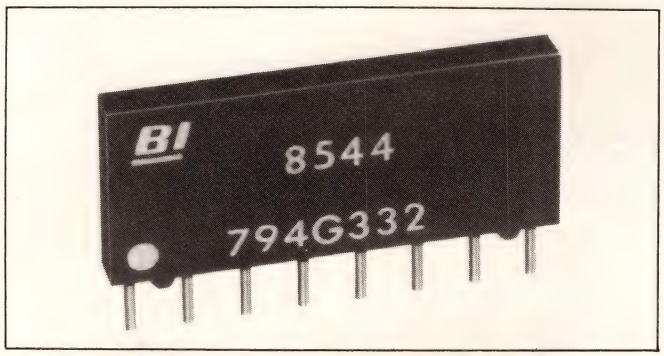
NiCr thin film called Ultrafilm. Based on an ion-beam sputtering process developed by Sfernice, the technology produces resistors with tolerances as low as ±0.01%, TCRs as low as 5 ppm/°C, and resistance values as high as 2 MΩ. The fabrication process yields a component density as high as 400 resistors per square centimeter and holds promise for integration with semiconductor processes. Standard products (RMK Series) include chip resistors for hybrid applications and networks that come in DIPs and TO cans.

Special-purpose parts will stay discrete

Numerous special-purpose resistor types are unlikely to be affected by the trends toward surface mounting and small size. Resistors that serve niche applications generally have radial or axial leads, and they are likely to remain that way. These include resistors optimized for high voltages, for high power dissipation, and for use in current-shunt, pulse-handling and microwave applications. Other types are guaranteed to be flameproof or guaranteed to act like a fuse when overloaded.

For example, Dale Electronics—a major supplier of thick-film networks and the leading supplier of wirewound leaded resistors—has recently introduced a family of high-power, small-geometry, flameproof resistors based on a proprietary NiCr metal film. These resistors, the CPF Series, come in five sizes with respective 1, 2, 4, 7, and 10W power ratings; the 1, 2, and 4W sizes have the same dimensions as standard RN55, RN60, and RN65 types, respectively. Compared with metal-oxide resistors, CPF Series parts offer lower TCRs (±100 ppm/°C) and lower tolerances (0.5, 1, or 5%). Resistance values range from 5Ω to 150 kΩ. Devices with 1% tolerance typically cost $0.16 (10,000).



A standard single-in-line package for thick-film resistor networks, *like this device from Beckman Industrial, has leads for through-hole mounting. The molded-epoxy housing is compatible with automatic-placement equipment.*

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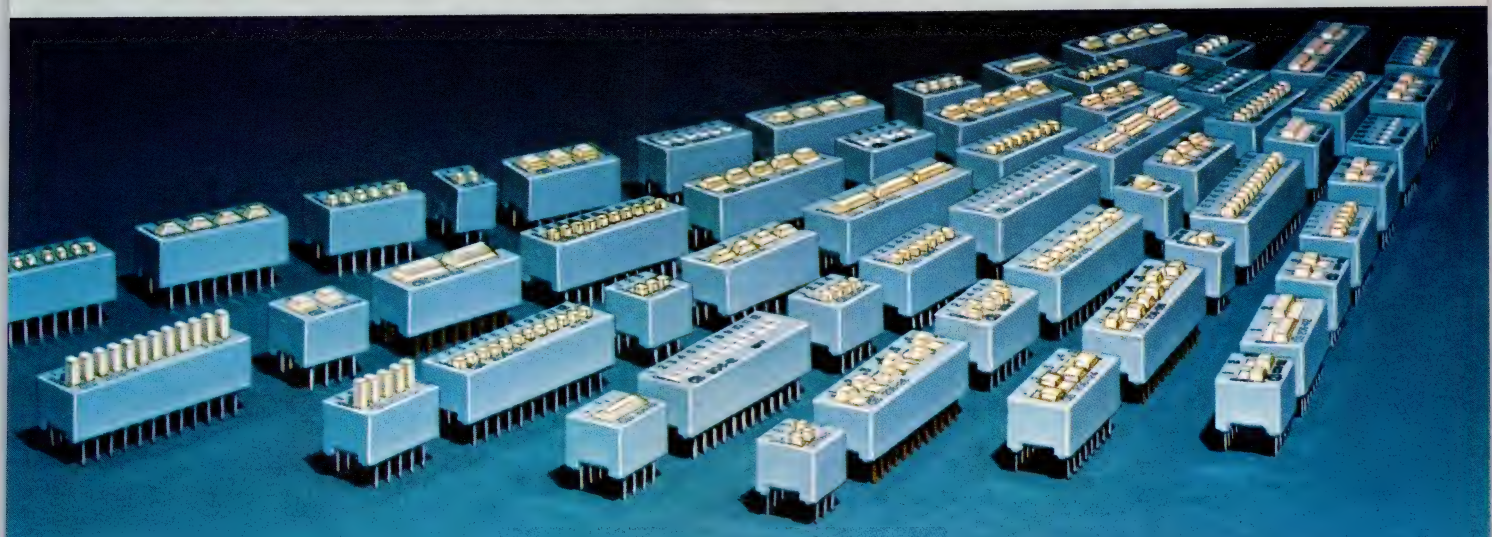

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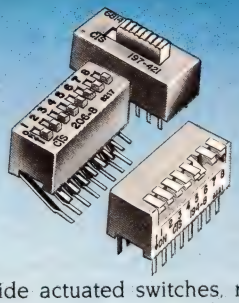

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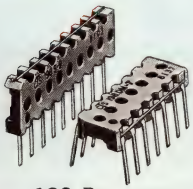

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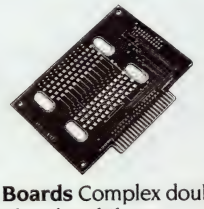

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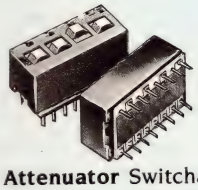

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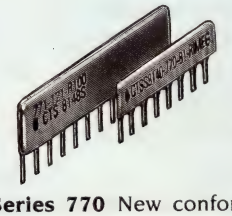
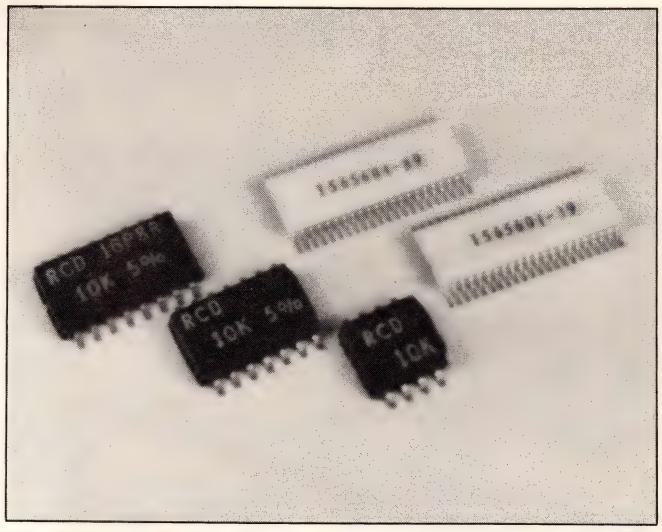


Series 770 New conformal coated SIP networks. Phone: (219) 589-8220
CIRCLE NO. 69

Networks are the obvious choice for digital systems, where pull-up, pull-down, and termination resistors usually occur in multiples of eight.

An ion-sputtering process produces these thin-film NiCr resistors *from Ultronix. The devices have the electrical characteristics of metal foil, but with a higher resistance—to 250 kΩ.*



Surface-mount resistor networks *from RCD Components Inc include the conventional small-outline type with gull-wing leads on 50-mil centers and a high-density package with leads on 25-mil centers. The high-density device concentrates 32 resistors in ⅛ in².*

Dale also offers the HVW metal-alloy resistors, which employ a special sealing process in lieu of a coating. The sealing process allows the devices to operate above 300°C while maintaining a ±5% tolerance. What's more, these resistors can operate in oil or inert atmospheres at temperatures above 200°C. Model HVW resistor values range from 500Ω to 200 MΩ. The resistors come in four sizes from ½ to 2W, with tolerances of 5, 10, or 20% and voltage ratings from 3.5 to 15 kV. A typical price for a 1W resistor is $0.40 (1000).

The type TG axial-leaded resistors from Caddock Electronics serve in high-voltage applications. These devices spec a 25-ppm/°C TCR over the −55 to +125 °C operating temperature range, for operating voltages to 30 kV. Based on the company's Tetrinox thick film, the resistors range in value from 1 to 600 MΩ and come in seven sizes; the largest is 6 in. long with a diameter of 0.350 in. All parts offer 0.25% stability per 1000 hours for full-load operation at 125°C. Prices range from $6.40 to $27 (1000). Also from Caddock, the type THV high-voltage divider networks offer 10-ppm/°C ratio TCs and 0.24% ratio tolerances when operating from 10 kV. These networks contain two resistors, come in 3-terminal SIPs, and cost $14.80 to $26 (1000).

Precision dividers suit instruments

Allen-Bradley also offers a precision voltage divider, in a 9-pin SIP. The thin-film divider, the FGST1000, contains six resistors ranging in value from 100Ω to 9 MΩ, and the divider provides six decades of attenuation for voltages as high as 1000V. The FGST1000 costs $24.42 (1000).

Corning Electronics makes the FP Series flameproof resistors, which withstand high-voltage pulses caused by lightning, rendering them suitable for use in telephone line cards and loop-interface equipment. Built with tin oxide on a cylindrical glass substrate, these resistors act like fuses when subjected to a sustained dc overload (the data sheets provide curves that let you predict such behavior). Specs include ½ to 3W power ratings, a 100 to 1000Ω resistance range, and tolerances of 0.5, 1, 2, or 5%. Prices for the FP Series range from $0.04 to $0.25 (1000).

Flame-retardant wirewound resistors from TRW have voltage-surge ratings five to 50 times higher than the ratings of equivalent film resistors. The manufacturer states that these resistors, the SPP Series, are lower-cost drop-in replacements for molded resistors. Specs include a 0.1Ω to 2.4 kΩ resistance range, 1, 2, or 3W power ratings, and 5 or 10% tolerance. Prices range from $0.061 to $0.123 (1000). **EDN**

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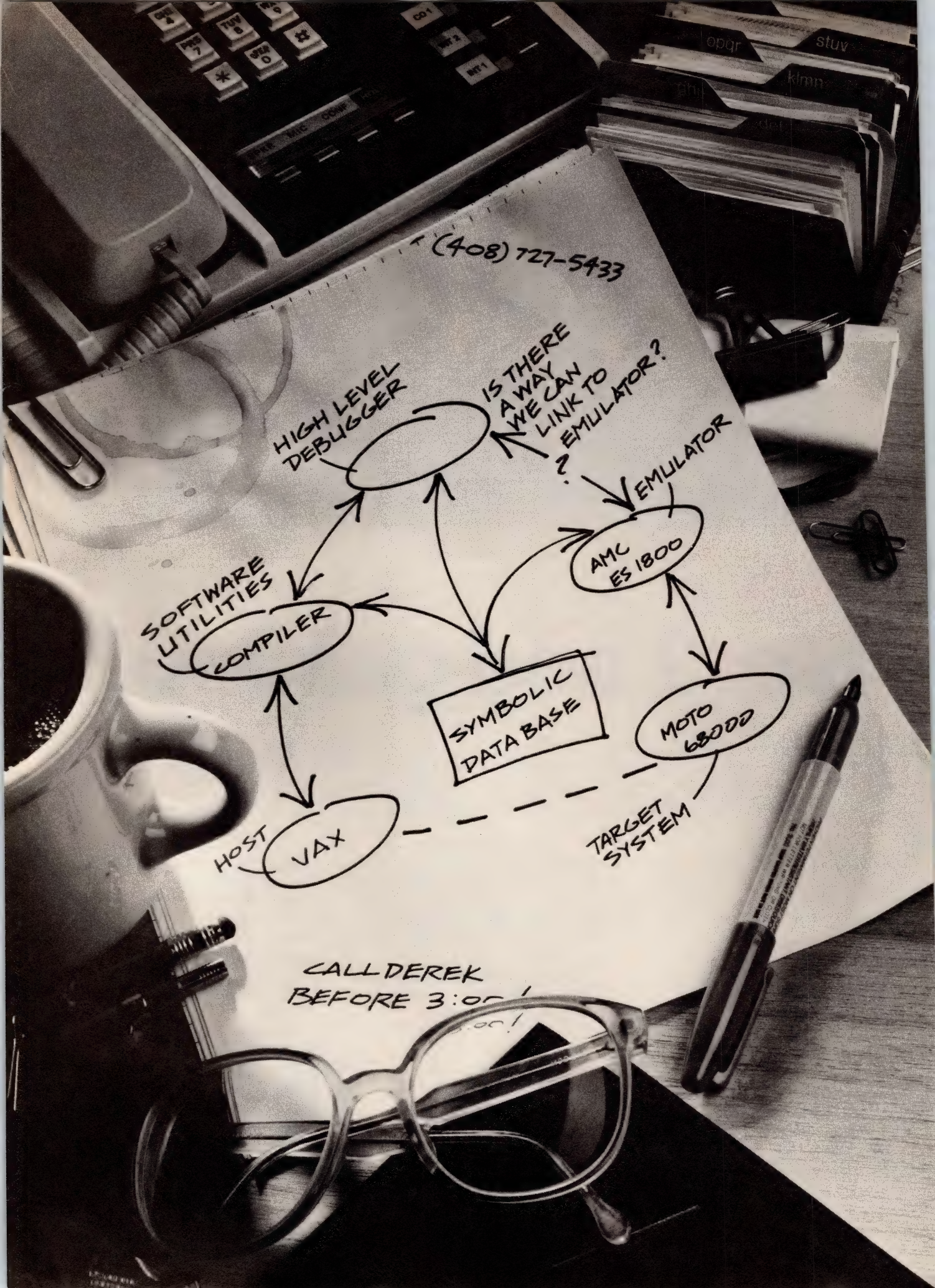
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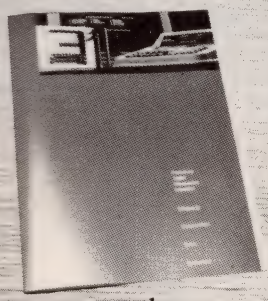

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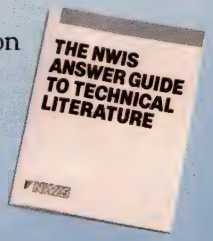

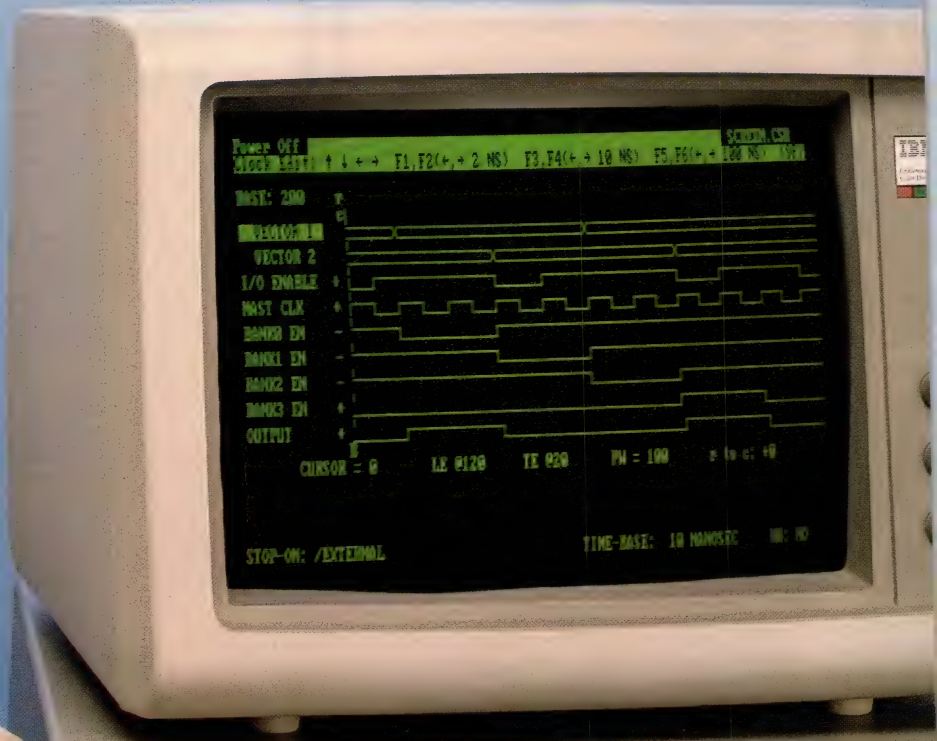

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Defensive programming simplifies program maintenance

By programming defensively, you can write software that adapts easily to changes in program requirements and hardware. Defensive-programming techniques also make your programs simple to read, to debug, and to modify.

EDN Staff

Almost all programs require modification after they're written, whether for debugging or for the purpose of incorporating new features. In fact, because of changes in hardware or in application requirements, many programs must be altered even before they're complete. You can simplify the modifications to your programs by employing defensive-programming techniques. Defensive programming—writing programs that are easy to change—saves time and money that you'd otherwise have to spend on program maintenance. If you program defensively, you can write software that will accommodate last-minute changes in requirements or hardware; you can also track down and fix bugs in your programs with relative ease.

To program defensively, you must first write a program that's easy to read and understand. Software engineers usually think of compactness and efficiency as being their primary programming goals, but a program that's extremely compact and efficient is not generally a very readable one. If written with just these two primary goals, even your own programs will be hard for you to read a few months after they're

```
/*************************************************************
**
**  init_io()
**
**  Initialize an 8-bit parallel I/O port.
**
**  Calling sequence:  outcome = init_io(addr, outs, states)
**
**  Parameters:        int addr -
**
**                        The base address of the I/O port
**                        Range: 0000 - 03FF hex
**
**                     char outs -
**
**                        Which bits in I/O port are outputs
**                        Set bits in output bit locations
**
**                     char states -
**
**                        The initial states for the outputs
**                        A set bit means TRUE
**
**  Returned:          int outcome -
**
**                        SUCCESS if all parameters in range
**
**                        FAILURE if a parameter out of range
**
**
**  This routine initializes an 8-bit parallel I/O port.
**  Parameters specify the base address of the port, what
**  bits are outputs, and what are the initial states for
**  those outputs.  This routine must be called before cal-
**  ling any routines to read inputs or write outputs.
**
*************************************************************/
```

Fig 1—A standard introduction for every routine *should include comments arranged in a uniform manner, as in this excerpt from a C program. These comments should tell at least the name of the routine, how to call it, what parameters are passed to it, what data it returns, and what it does.*

To program defensively, you must write a program that's easy to read, to understand, and to modify.

written. If other people will be maintaining your programs, it's even more important that your software be readable. It's worthwhile, therefore, to trade off some of your program's compactness for readability.

Making a program readable

The first step you can take to make a program readable is to make liberal use of comments. Make sure that you preface your routines with comments, and that you follow a consistent format. These comments should tell at least the name of the routine, how to call it, what parameters are passed to it, what data it returns, and what it does. It's best to arrange the comments uniformly and to call attention to them, perhaps by placing a box of characters, such as asterisks, around them (see **Fig 1**).

Programming modules also require introductory comments. The first page of a module should give the name of the author as well as those of the source and object files. It should also include a brief description of the module and contain the module's revision history. The preamble should list and describe all the module's routines in the order in which they occur in the module **(Fig 2)**. When you look at a module that begins this way, you can easily see what it contains.

```
/*
**   Module:   iocontrol.c    (I/O Control)
**
**   Object file name:  iocontrol.obj
**
**   Author:  WCW
**
**   Revision history:
**
**      02/11/86  WCW - Created
**
**
**
**   This module contains routines for initializing an I/O
**   port, and for reading inputs and controlling outputs.
**
**   This module contains the following public routines:
**
**      init_io()         Initialize I/O
**      logged_true()     Make output LOGGED true
**      logged_false()    Make output LOGGED false
**      read_logdata()    Read and return state of LOGDATA input
**      read_estop()      Read and return state of ESTOP input
**
**   You must call init_io() before calling any other
**   routine in this module.
**
**   Callers of these routines must #include header
**   iocontrol.h which defines the return types of the
**   routines, constants for passing to the routines, and
**   constants returned by the routines.
*/
```

Fig 2—The first page of a module *should include the names of the source and object files, the author's name, the module's revision history, and a brief description of the module. As in this extract from a C program, the preamble should list and describe all the module's routines in the order in which they appear in the module.*

To be readable, a program must be organized well. The easiest way to organize a program is to use a structured language, such as Pascal or Ada, and adhere rigorously to structured-programming principles. For one thing, a program written in a structured language will almost never require GOTO statements, statements that can be confusing. If you must use a nonstructured language (such as assembler), you can help keep your code clear by restricting your use of GOTO statements. Use GOTOs only for implementing the branches required for looping and for statements such as IF . . . THEN . . . ELSE statements.

Of course, it's hard to adhere strictly to structured-programming principles when you're writing in assembly language. However, you can program defensively in assembly language by making sure that at least the highest levels of the program—the levels that control the flow of the program—are structured. If you must, you can then write unstructured low-level routines.

Organize program statements

You can also make a program easy to read by organizing the placement of the program's statements on the page. You should limit the highest level of program logic to a single page. This main program should consist of a loop (perhaps even an endless loop) of decisions and subroutine calls. The details of your program should reside on other pages, in the subroutines that are called from within the loop. And you should write short subroutines, again separating details from logic.

By separating program logic from details, you'll spare the reader having to slog through the details of a program's implementation while learning its structure. Placing code in subroutines makes the main routine shorter, and it may let you avoid crossing a listing-page boundary inside the body of a loop. It's worthwhile even if it merely lets you keep an IF clause and an ELSE clause near each other on a page.

Use mnemonics

When you're programming, choose mnemonic (memory-aiding) names for constants, variables, routines, and modules. You could, for example, use a routine's name to tell what the routine does, as in the following names: find_last(), check_input(), log_datum(). It's worthwhile to use mnemonic names even when you're programming in languages that limit labels and symbols to six or eight characters.

If you're writing in a nonstructured language, such as Basic, Fortran, or assembler, you must often label statements within a routine. It's best to label these statements sequentially, not mnemonically. If the language allows, form the labels from characters resembling the routine name and a numerical suffix. For example, in the subroutine Output, your labels would be OP1, OP2, OP3, etc. Of course, the statement GOTO OP2 is less meaningful than the statement GOTO EXIT; however, sequential labeling makes referenced statements easy to locate. If you use a comment with each reference to a sequentially labeled statement, the program flow will be clear.

Isolation through funneling

To program defensively, you must not only write a program that's easy to read and well organized, you must write one that's easy to change. One way to write programs that are easy to change is to use the funneling technique. Funneling also makes the program relatively independent of data-structure changes.

Funneling is the practice of isolating the main body of the program from some small part that may change by routing all access to that part through dedicated routines. These routines mask their own internal details, which are subject to change, from the rest of the program. Although the masking routines may change internally, they always appear the same to calls from the rest of the program.

Program to support changes

I/O and data structures are good candidates for isolation by funneling. Imagine, for instance, that you're programming an instrument that accepts the input signal Logdata and responds with the output signal Logged. Suppose that because of hardware-design changes, you must invert the sense of Logdata or change its input-pin assignment.

The funneling technique lets you defend your program against these changes. Using this technique, you dedicate a routine to reading, and answering all inquiries about, the logic state of Logdata. That routine will return a True or False code regardless of how the actual circuitry defines True and False. It's a good idea to require the rest of the program (and any other programmers working on it) to use this routine.

By funneling all inquiries about the state of the input through a single routine that returns merely True or False, you make that one routine absorb the impact of a hardware change. When a hardware change occurs, then, you'll need to change only the logging routine; no other code will be affected.

Similarly, you can dedicate one routine to making the output signal (Logged) True and another to making it False, and you can require all access to this output to funnel through these two routines. If the logic designer alters the output circuitry, then these routines will be the only ones you need to modify.

Funneling hides data structure

You can also make the program access complicated data structures by funneling. Funneling relieves the calling program of the task of dealing with the complexities of the data structure. For instance, you can access the data structure with the same command, whether the structure is maintained in main memory, on a local disk, or on a remote file server.

Dedicated routines should also be the only ones to access any complicated data structure, such as a queue. Instead of making the data itself public, you funnel access to the data through the support routines. Funneling hides the details of how the program stores and receives data, and it shields calling routines from changes in the organization and size of the data structure.

To funnel data, you'll require at least three routines: a routine to initialize the data structure, a routine to enter data, and a routine to return data. Sometimes you'll need two additional routines: one to copy the data from disk into memory and one to write data from memory to disk. A good plan is to make a module that comprises the three (or five) data-structure routines, the (nonpublic) memory allocated for the data structure, and whatever local routines the public routines may require.

This module will be, in effect, a packaged resource that's available for use by the rest of the program. Changes in data storage and retrieval methods, the data structure's size or organization, and the way the data moves between memory and disk, therefore, will probably not affect anything outside the data-structure package.

Table-driven routines

Another way to write programs that are easy to change is to employ table-driven routines, which make your overall program insensitive to changes. A table-driven program or routine is one whose behavior is determined in large part by the contents of a table or tables. The executing code merely interprets the con-

Software engineers usually favor compactness and efficiency over other programming goals, but compact programs are generally not very readable.

tents of the tables. To change the program, you simply change the data in the tables.

Assign names to constants

When you're programming defensively, you should always take advantage of the opportunity to assign names to constants (such as EQU, #define, Literal). You should name constants for two reasons. First, an apt name is more meaningful than a raw constant when you encounter it in a listing. Second, if you ever need to change the value you've assigned to a constant, you need change only the statement that assigns the constant its value, instead of having to change that value wherever it appears in the program.

Note that the advantages of using shortcuts can become disadvantages when you're performing program maintenance. If, for example, your program tests a certain variable to see if it's equal to some constant, which happens to be zero, you shouldn't test to see if the variable is equal to zero. Although such a test would be compact and would execute quickly, it would be hard to modify: If you were to redefine the constant, you'd have to modify all the code that tests for zero. Instead, you should test the variable for equality to the constant symbol; you could then modify the constant by changing only one statement.

Beware of loader initialization

In big systems, and in an increasing number of smaller ones, a loader places a program in memory before each run of the program. Programming languages allow you to assign initial values to variables, arrays, etc; the loader makes those initializations for the newly loaded program before the program runs.

In some systems, however, a program undergoes the loading process only once and then remains in memory to be executed time after time. Furthermore, many computer-based instruments and controls have no loaders at all. These instruments' programs, which reside in read-only memory, begin running the moment the power is turned on. The programs must therefore include code that performs all initialization, because there's no loader to put things into a known initial state.

Occasionally, you need to take a program from a system that employs a loader and use it on another system that doesn't. If this program relies on loader initialization, you'll have to add the code that can perform the necessary initializations. If you want to program defensively, you'll always write initialization code when you write a program.

You can also use defensive-programming techniques in assembly-language programming. For example, you can follow conventions for register usage, parameter passing, and stack usage. You can adopt a convention for the use of registers by subroutines, deciding which registers a subroutine may alter and which ones it must preserve. That way, you know which registers you can use when you're changing a subroutine.

You may also wish to standardize the manner in which the program receives parameters and returns data, instead of letting each subroutine perform these functions differently. You can decide, for example, always to return 8-bit quantities, right-justified, in a certain register; 16-bit quantities in another register; and 32-bit numbers in a certain pair of registers, one of which will always contain the most significant part of the number.

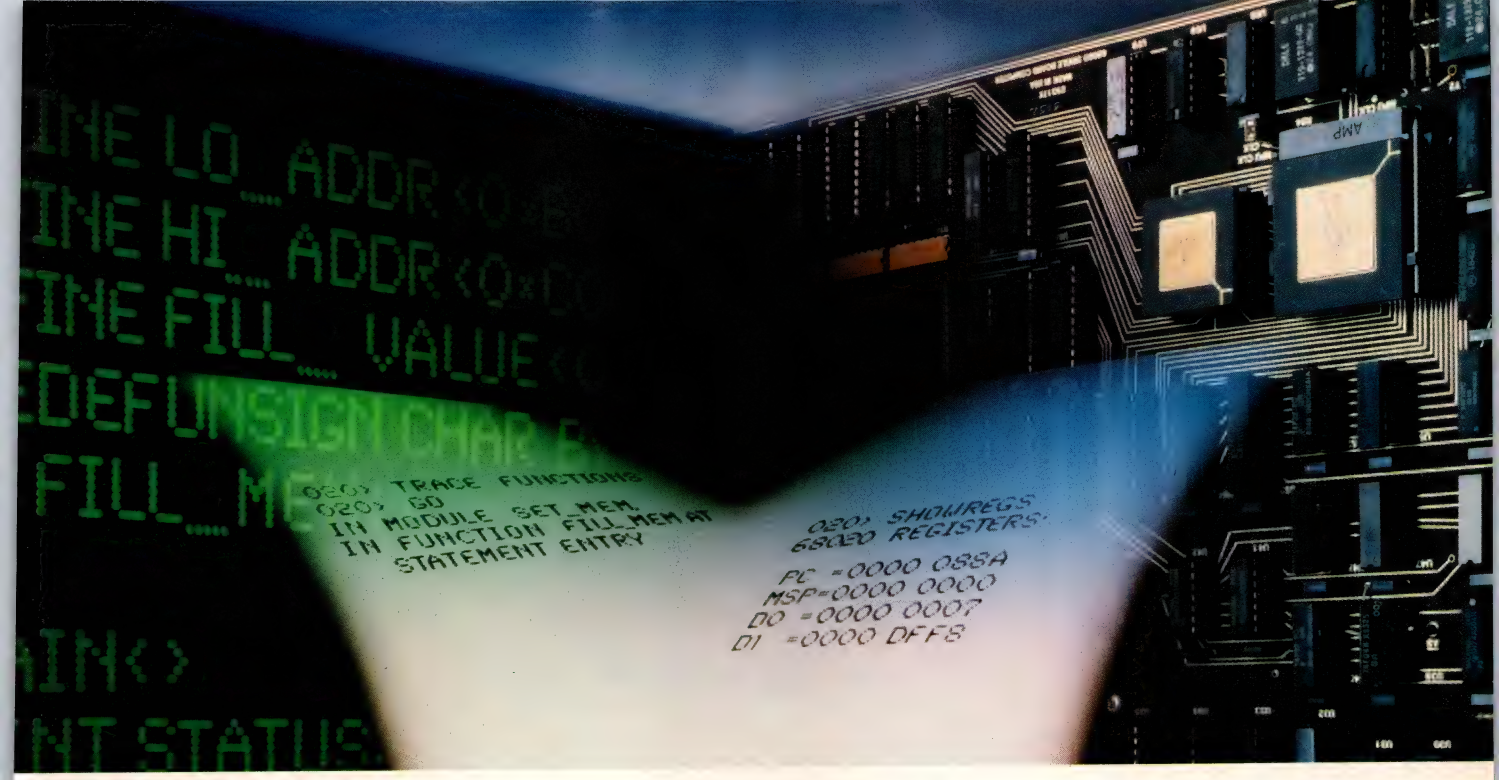
Use the stack carefully

Finally, you should always be cautious in your use of the stack. Although the stack is useful for passing parameters and for temporary storage, poor use of the stack can cause headaches both when you're initially writing the program and when you're modifying it later.

Problems can arise, for instance, when you jump within a routine after you've used the Push instruction to place an item on the stack for temporary storage. You may have trouble finding the right place for the Pop instruction, which will remove the item from temporary storage. You could put the Pop instruction at the end of the routine near the exit, but if you later add a path through the routine that bypasses the Push command, the Pop command will corrupt the stack.

If you've stuck to a rigorous structure for your assembly-language routine, however, you'll be able to find the correct place for the Pop instruction so that it will be executed only after its corresponding Push instruction. If you haven't structured your routine rigorously (as is more likely), you'd do best to avoid branching when there are items on the stack other than the registers that are routinely saved. **EDN**

This article was developed by EDN editors based on information received from a software consultant.



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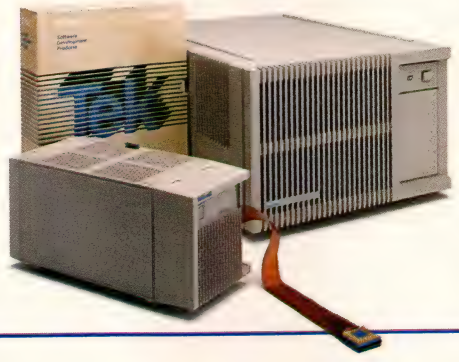

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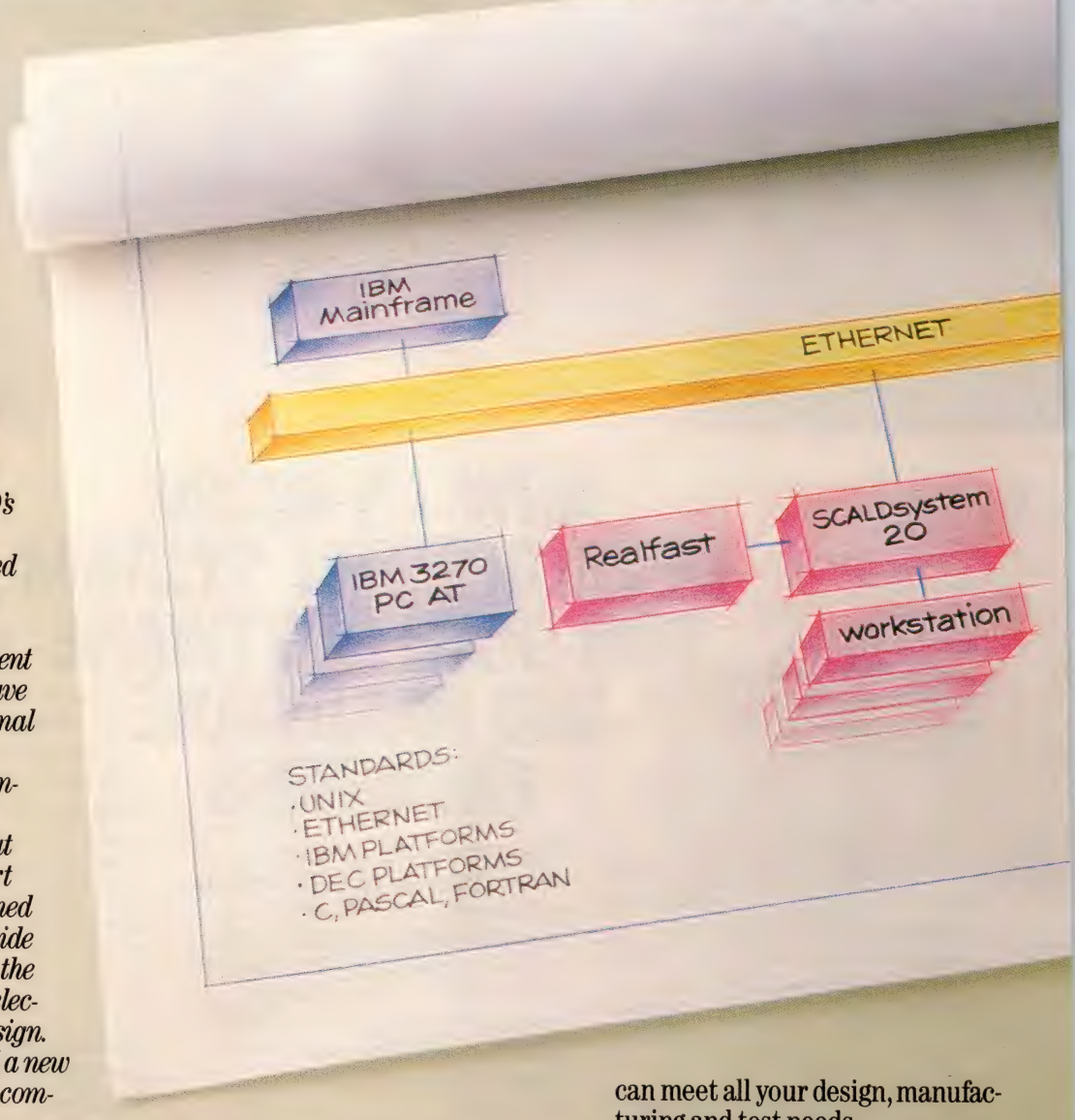

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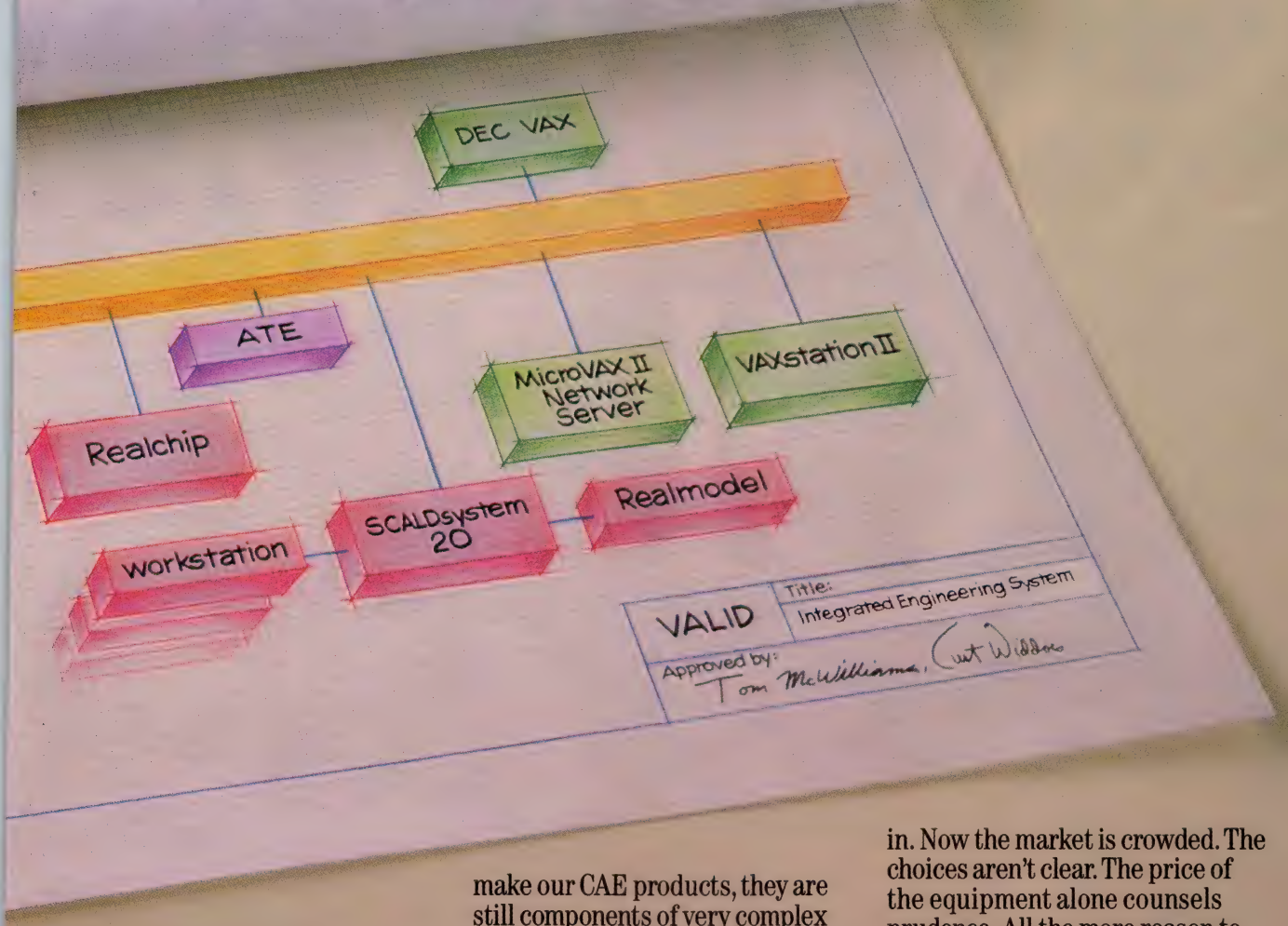

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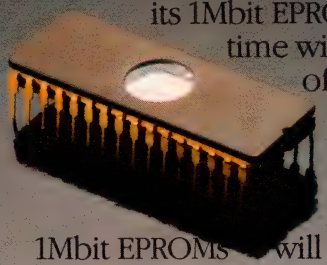

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μP-based control scheme can enhance printer performance

Split-second timing performance is an absolute must in high-speed daisywheel printers. A master/slave μP control system can readily satisfy this requirement. Combining a burst- or interrupt-interface system with a time-sharing acknowledge strobe contributes to this efficient and economical way of operating printers.

Don Dempsey, *Xerox Corp*

Today's state-of-the-art daisywheel printers incorporate special circuitry to maximize printing efficiency and speed. A circuit design scheme that employs multiple μPs is a cost-effective means of controlling the operation of such printers. In this scheme, a master processor (MP) accepts inputs from the host (the computer, or controller, that sends commands to the printer), translates them into various subcommands, and sends them to the slave processors to carry out the desired printing operations.

A printer's control board can contain multiple slave processors, but for purposes of simplicity, consider a design scheme that employs just two—the primary slave (PS) and the secondary slave (SS) **(Fig 1).** The PS accepts commands from the MP, processes them, and then relays instructions on to the SS if necessary. In the Xerox/Diablo D80 daisywheel printer, for example, the PS controls the printwheel-seek and paper-handling tasks, whereas the SS controls the carriage-motion, ribbon-advance, and printer hammer-firing functions and the on-the-fly-printing algorithm.

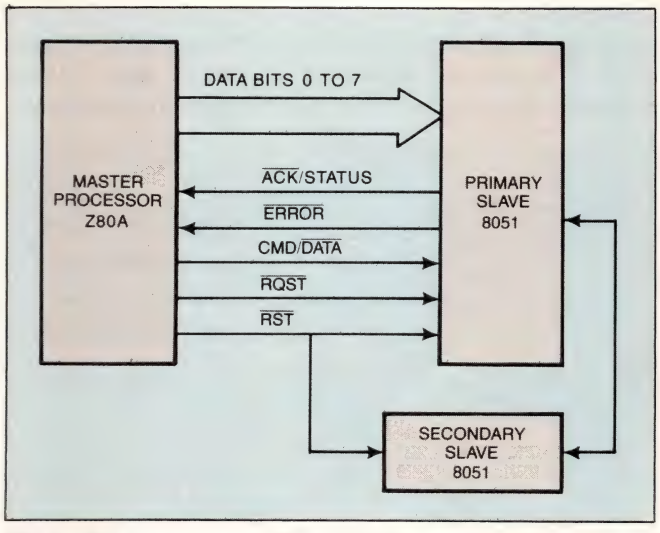


Fig 1—You can economically control *the operation of high-speed daisywheel printers by using a scheme that employs one host μP and two slave processors.*

Typically, you need an 8-bit parallel bus for the MP to communicate with the PS: The MP constantly transmits many commands and large amounts of information. However, for the PS to communicate with the MP, you only need a one-way serial bus because the information

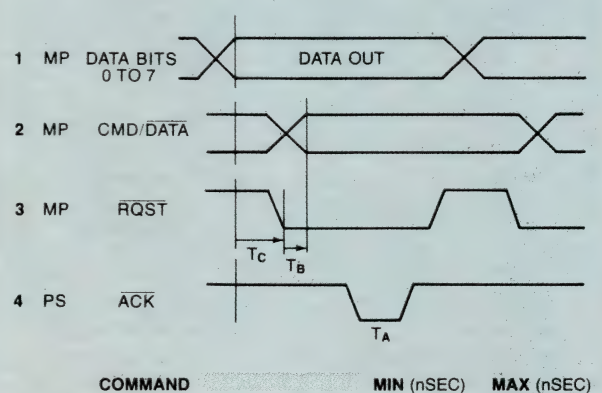
By keeping the control scheme's program modular, you can easily accommodate a variety of printers by changing only a few sections of the program.

flow in this direction is considerably lighter.

You can use the serial bus in one of two ways: to send a single command-received acknowledge signal or, in a time-sharing mode, to return an acknowledge signal plus a particular data bit requested by the MP. The time-sharing capability (**Fig 2**) has an obvious advantage—economics. The ability to transmit two messages on one interface line in response to one command signal reduces hardware costs.

To illustrate how the time-sharing process works, assume that the MP sends a message to the PS, requesting paper-out status. First, the PS sends an acknowledgment to the MP to confirm message reception. On the same line, the PS also sends a high or low value to indicate whether the status is true or false (whether paper is or isn't available).

Fig 3 outlines the steps that make up the time-sharing process. To start, the MP sends a Status Read command telling the PS that it wants some status information. The PS then acknowledges receipt of this message. Next, the MP sends a message that defines what it wants to receive—in this case, paper-status condition. The PS acknowledges receipt of this message and, with the same signal, sends a high or low value to indicate a paper-in or paper-out condition. The MP reads this data and then sends a message to indicate receipt. To terminate the process, the PS acknowledges the MP's message that it's received the requested information.



COMMAND	MIN (nSEC)	MAX (nSEC)
T_A=ACK PULSE WIDTH	20	—
T_B=RQST TO C/D VALID DELAY	20	20
T_C=DATA VALID TO RQST DELAY	500	—

NOTES:
1. MP SENDS COMMAND OR DATA TO PS.
2. SIGNAL LINE FROM MP TO PS DENOTES WHETHER OR NOT #1 IS A COMMAND OR ADDITIONAL DATA WITH A PREVIOUS COMMAND.
3. MP REQUESTS THAT PS PERFORM OPERATION.
4. PS GENERATES ACKNOWLEDGE STROBE TO MP.

Fig 2—By time-sharing the acknowledge strobe, *the master/slave μP control scheme allows you to transmit two messages on the same interface line with only one command signal.*

If the paper leading-edge sensor can't see paper in the designated tray at any time during the printing operation, it creates a paper-out error condition. The SS notifies the MP of this situation by sending an Error Interrupt signal. However, the MP has no idea that it's receiving this error signal from the SS: It recognizes only one slave, the PS, and sends all messages only to the PS. The SS receives all its inputs from the PS. Not until the operator corrects the paper-out error condition and presses the start button does the MP restore printer operation and try to re-establish the previous printing sequence.

Structuring the processors in this way—one master and one or more slaves—has a particular advantage. It makes the high-level segment of the processing more machine independent; the control board contains all of the intelligence, which constitutes the commands that the printer executes. And, the escape sequences contain the master interface's intelligence, which is what the host sees.

The software, algorithm, and communications interface are fairly difficult to develop, but by keeping the high-level algorithm isolated from any dependency on the low-level machine, it's possible to use the same architecture or software command structure for a variety of daisywheel printers—or printers in general, for that matter. As a result, you can avoid having to rewrite long and complex code every time you need a control scheme for a new machine. By keeping the program modular, you can easily change certain sections to suit the printer in question without affecting other sections.

An interrupt- or burst-interface system easily allows you to increase the data-transfer rate between the MP and PS. With such a system, the MP can send data as fast as the PS can receive it: The PS sends an Acknowledge signal (an interrupt) to the MP, indicating that it's completed work on the previous command, or it sends a Ready signal, indicating that it's available for the next command.

Such a sequence allows the MP to process other information from the host between bursts from the PS, and thereby increase system efficiency. The MP doesn't have to wait idly while the PS processes a command,

nor does it lose any additional time should the PS have to relay any commands on to the SS. This interface scheme, in essence, minimizes wasted time.

By examining the precise timing requirements of the on-the-fly-printing algorithm in the D80 daisywheel printer, you can see how the MP, PS, and SS are able to interface and thus coordinate printer motion. When the process begins, the PS executes the printwheel-seek task and coordinates the platen-motion and sheet-feeding operations when necessary. The SS advances (steps) the ribbon, and the carriage is in motion because it hasn't stopped since printing the previous character. The algorithm's design allows the printwheel-seek and ribbon-stepping operations to finish just before the carriage moves into the desired print position. The printer hammer (which the SS also coordinates) fires 3 to 5 msec before the carriage is in position. By the time the spoke hits the paper, therefore, the carriage has reached the correct print position, and everything else is in a quiescent state.

The MP calculates all these tasks three characters ahead of time. All the tasks are interdependent, and all are constantly changing, depending on the previous, current, and next character. On the average, the master sends five bytes of information to the slaves to print each character, including such information as printwheel spoke-number, ribbon-advance size, hammer energy-level, and carriage distance.

The PS operates the printwheel-seek, platen-motion, and all sheet-feeding operations one step at a time. SS, on the other hand, coordinates the carriage, ribbon, and printer-hammer commands in parallel. At 80 cps, the master must transmit to the slave approximately 400 command bytes/sec to operate without dropping out of the on-the-fly-printing mode. In addition, if you desire bidirectional printing, the master processor must stay one full line ahead.

The on-the-fly-printing algorithm requires a significant amount of signal processing. As a result, the communications link must be a high-speed one. Also, the control system must off-load as many hardware-dependent processes to the slaves as possible, even if it means having to use more than two slaves. Otherwise, the MP would spend most of its time processing these time-critical commands, and have little time left to coordinate anything else.

The master/slave configuration isn't the only control-circuit design scheme available. You could, for example, use one very large master processor to carry out all processing functions. This alternative nonetheless has some disadvantages. To begin with, it's more expensive. In addition, the modular code would have to be very complex, and developing it would be very difficult and time-consuming. As a result, you'd probably wind up with as much hardware as the master/slave configuration requires, anyway. All in all, the master/slave configuration is a more cost-effective solution because slave processors are relatively inexpensive and developing the requisite firmware is much easier. **EDN**

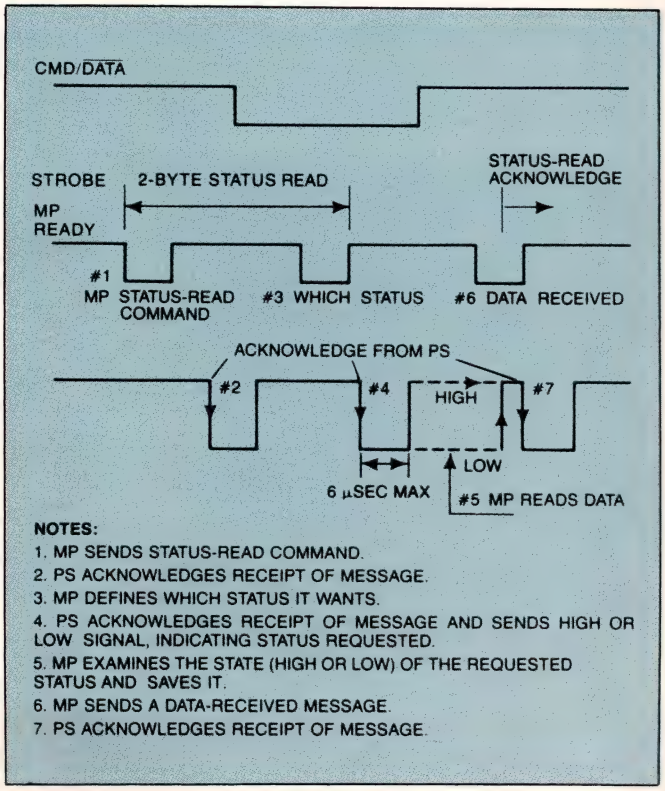


Fig 3—The time-sharing strobe concept *involves seven steps. It starts when the MP sends a Status Read command to the PS, and ends when the PS acknowledges the MP's message that it has received the requested information.*

Author's biography

Don Dempsey is vice president of sales and marketing at Xerox Corp's Printing Systems Div (El Segundo, CA). A company employee for 18 years, he holds a BS degree in math from St Peter's College (Jersey City, NJ), and an MA degree in math from the University of Detroit. In his spare time, Don enjoys tennis and sailing.

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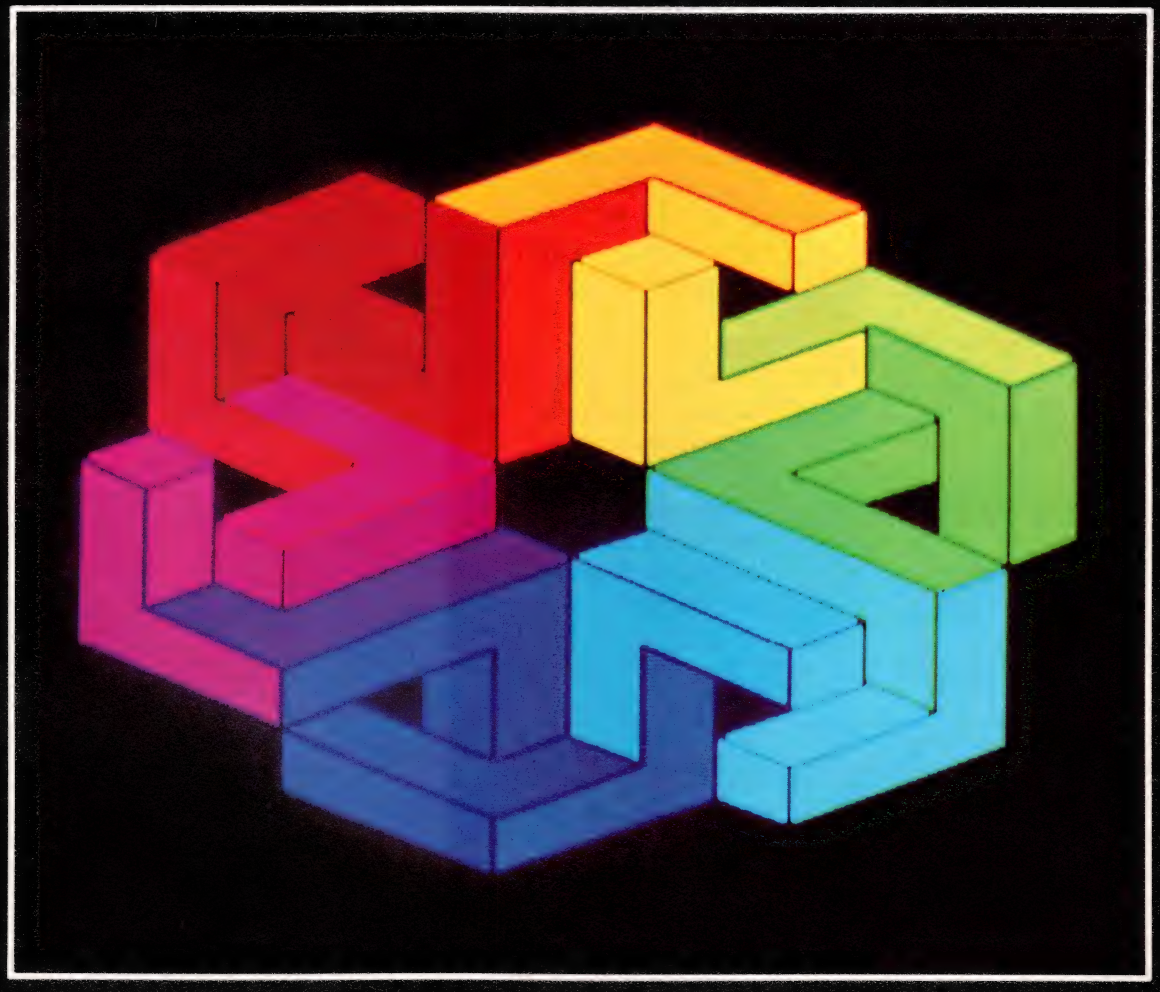

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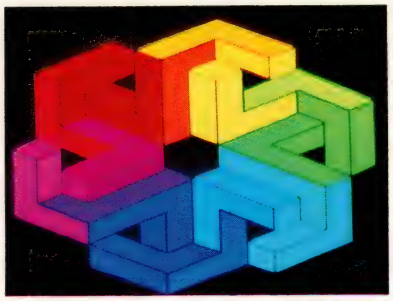

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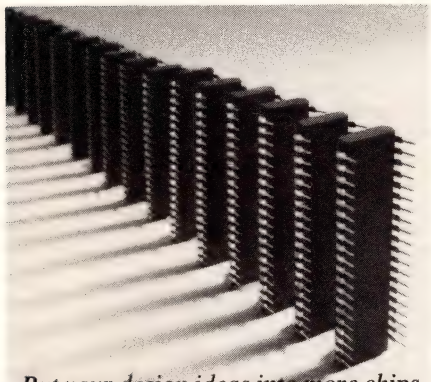

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Carrying two capacitors, chopper-stabilized op amp performs with precision. *Freeman, Wes, Teledyne Semiconductor; Electronic Design, 11/14/85, pg 184, 3.5 pgs.*

Hybrid and monolithic A-D converters push toward 1 MHz and beyond. *Marrin, Ken, Senior Editor; Computer Design, 11/15/85, pg 37, 3 pgs.*

Hybrid converters rise to the challenge of real-time signal processing. *Spadaro, Joseph J, Associate Editor; Electronic Products, 02/03/86, pg 52, 5 pgs.*

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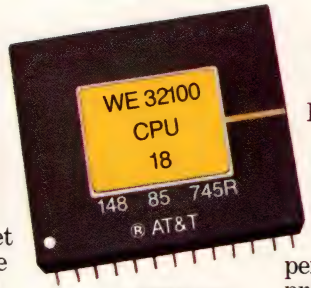

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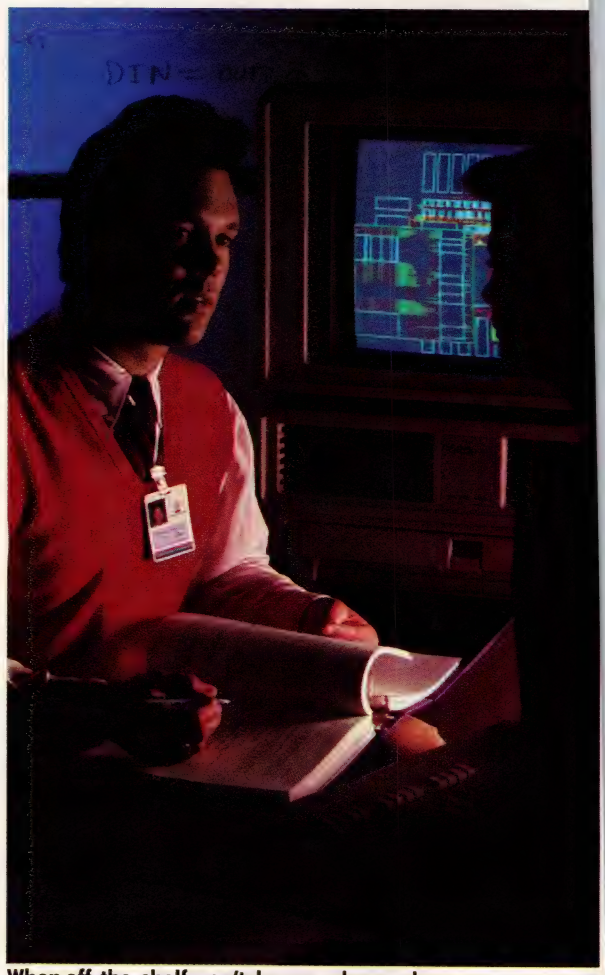

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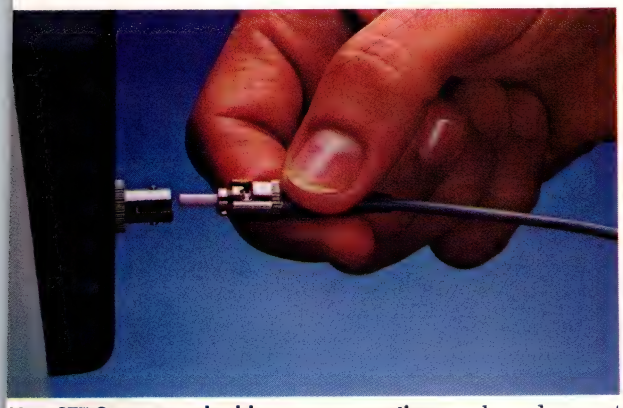

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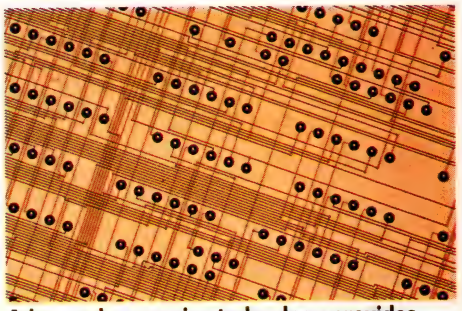

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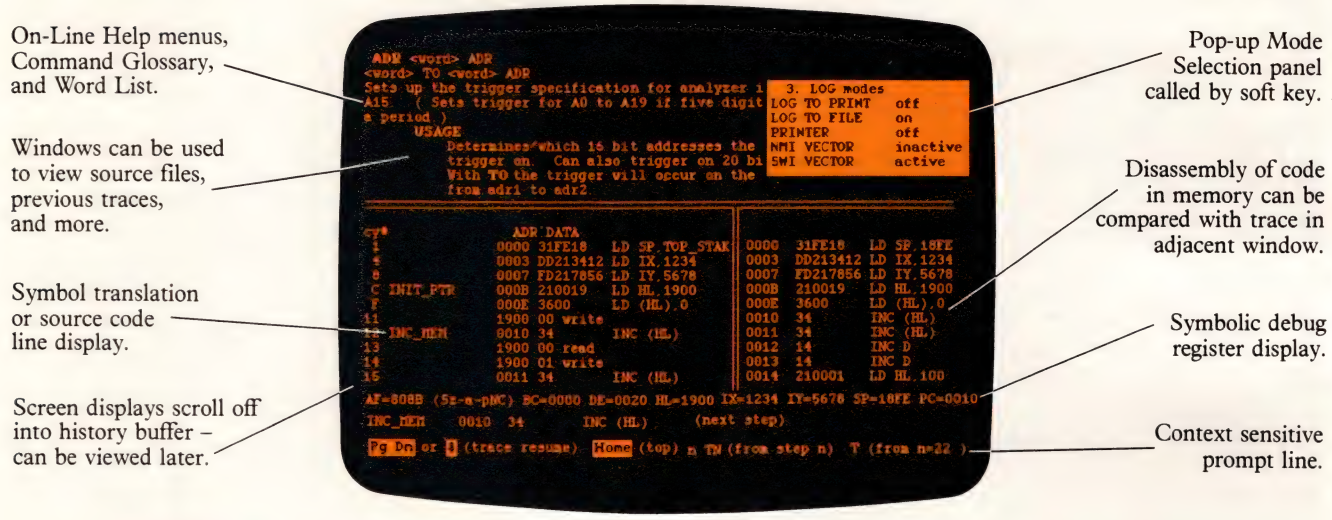

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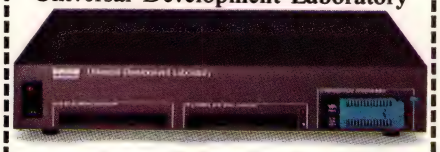

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Hardware and software in development tools make processing chips purr. *Loewenstein, Paul, Fairchild Camera/Instrument; Electronic Design, 11/28/85, pg 135, 4.5 pgs.*
Programming aids minimize errors during software design, coding, and modification. *Terry, Chris, Associate Editor; EDN, 04/17/86, pg 79, 6 pgs.*

Programming
Interfacing routines bridge the gap between languages. *Staub, Phil, Tektronix; Computer Design, 11/01/85, pg 115, 5 pgs.*
Need for software testing moves into spotlight. *Suydam, Jr, William E, Contributing Editor; Computer Design, 11/01/85, pg 54, 4 pgs.*
Programming aids minimize errors during software design, coding, and modification. *Terry, Chris, Associate Editor; EDN, 04/17/86, pg 79, 6 pgs.*
Software links math chip to 68000-family μPs. *Harris, Sarah, Motorola; Johnson, Tom, Motorola; EDN, 01/23/86, pg 175, 12 pgs.*

Prototyping boards/systems
Board prototyping closes the gap in concept-to-board automation. *Bloom, Michael, Contributing Editor; Computer Design, 12/85, pg 34, 3.5 pgs.*

R

RS-232/422 interfaces
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Board-mounted regulators put power where it's needed. *Hoffart, Fran, National Semiconductor; Electronic Products, 12/16/85, pg 37, 5 pgs.*

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Electromechanical relays are alive and well. *Chin, Spencer, Associate Editor; Electronic Products, 02/03/86, pg 46, 5.5 pgs.*

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16-bit digital systems force front-end designers to review analog rules. *Palocsay, Leslie, Analog Solutions; Electronic Design, 11/21/85, pg 121, 5 pgs.*

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S

STD bus
Run a 68008-based 1-board computer on the STD Bus. *Spurrier, John H, Spurrier Peripherals; EDN, 11/14/85, pg 247, 5.5 pgs.*

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An economical way to handle digital TV satellite signals. *Staff; Electronics, 11/18/85, pg 50, 3 pgs.*

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Analog standard cells still more custom than semicustom. *Bloom, Michael, Contributing Editor; Computer Design, 03/15/86, pg 28, 4 pgs.*
Analog standard cells. *Goodenough, Frank, Technology Editor; Electronic Design, 01/09/86, pg 136, 7 pgs.*
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Found: the final link to the one-chip system. *Staff; Electronics, 03/17/86, pg 30, 5 pgs.*
How Mosis will slash the cost of IC prototyping. *Waller, Larry, Los Angeles News Bureau Mgr; Electronics, 03/03/86, pg 48, 2 pgs.*
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Shaft encoders angle in on new position-control needs. *Chin, Spencer, Associate Editor; Electronic Products, 04/15/86, pg 42, 6 pgs.*

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RF modulator features two power MOSFETs. *Lockwood, Larry, Tektronix; EDN, 11/28/85, pg 282, 1 pg.*

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Degree of PHIGS/GKS compatibility still hotly debated. *Williams, Tom, Western Managing Editor; Computer Design, 12/85, pg 38, 2 pgs.*
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Data-line standards keep pace with technology. *Pippenger, Dale, Texas Instruments; Electronic Products, 11/01/85, pg 97, 5 pgs.*
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Floating-point math handles iterative and recursive algorithms. *Ashton, Charlie, Advanced Micro Devices; EDN, 01/09/86, pg 115, 6.5 pgs.*
Floating-point methods combine to boost performance. *Porter, Kent, Fairchild Camera & Instrument; Kath, James, Fairchild Camera & Instrument; Computer Design, 02/01/86, pg 75, 5 pgs.*

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Computers tackle challenges of the 90s. *Killmon, Peg, Senior Editor; Computer Design, 12/85, pg 47, 7 pgs.*
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T

TTL logic
Advanced CMOS logic presents stiff competition for Schottky. *Bernhard, Robert, Electronic Design, 04/17/86, pg 77, 5 pgs.*

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Graphics ICs provide high-resolution, color CRT displays. *McDonough, Kevin, Texas Instruments; Computer Design, 01/01/86, pg 85, 5 pgs.*
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Testing (nonproduction), troubleshooting and measurement, other
Forging links between board design and test. *Milne, Bob, Technology Editor; Electronic Design, 03/20/86, pg 94, 6 pgs.*

Testing techniques
Self-testing ICs begin to emerge—tentatively. *Mendelsohn, Alex, Electronics, 02/24/86, pg 33, 4 pgs.*
Solving the test problem in SCSI disk drives. *Staff; Electronics, 02/17/86, pg 35, 3 pgs.*

Timer ICs and circuits
CMOS chips cut timer's power consumption. *Proctor, John J, National Semiconductor; Kim, Peter, National Semiconductor; EDN, 12/12/85, pg 266, 1 pg.*

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Balanced lines handle higher data rates amid noise. *Pippenger, Dale, Texas Instruments; Electronic Products, 11/15/85, pg 64, 6 pgs.*
Built-in bus drivers let transceivers steer data between ports. *Hefner, Charles, Texas Instruments; Liem Nguyen, Thanh, Texas Instruments; Electronic Design, 01/09/86, pg 231, 4 pgs.*
Correct choice of protocols increases noise immunity. *Gray, Nicholas C, Signetics; Computer Design, 11/01/85, pg 125, 6 pgs.*
Data-line standards keep pace with technology. *Pippenger, Dale, Texas Instruments; Electronic Products, 11/01/85, pg 97, 5 pgs.*
ICs simplify design of single-sideband receivers. *Zavrel, Robert J, Signetics; EDN, 04/03/86, pg 119, 7.5 pgs.*
Serial datacomm driver/receiver ICs furnish higher data rates, lower power consumption. *Cormier, Denny, Western Editor; EDN, 01/23/86, pg 93, 4 pgs.*
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U

UNIX
Chip set geared to Unix simplifies high-end designs. *Hayes, Norman M, AT&T Technology Systems; Computer Design, 01/01/86, pg 65, 5.5 pgs.*
Realtime and multiuser operating systems target IBM PC AT. *Marrin, Ken, Senior Editor; Computer Design, 12/85, pg 135, 6.5 pgs.*
Two is better than one. *Hindin, Harvey J, Special Features Editor; Computer Design, 04/01/86, pg 49, 11 pgs.*
Unix: the birth of a standard. *Walthers von Alten, Judith, Northwestern Editor; Electronic Products, 02/17/86, pg 49, 4 pgs.*

V

VME bus
Battle of the buses: And the winner is.... *Rosenberg, Robert, Communications Editor; Electronics, 11/25/85, pg 48, 4 pgs.*
Bus differences more significant in principle than in practice. *Marrin, Ken, Senior Editor; Computer Design, 11/01/85, pg 23, 3.5 pgs.*
Designers confront metastability in boards and buses. *Beaston, John, Intel; Tetrick, R Scott, Intel; Computer Design, 03/01/86, pg 67, 5 pgs.*
New silicon intensifies debate over VMEbus/Multibus II multiprocessor support. *Marrin, Ken, Senior Editor; Computer Design, 01/15/86, pg 31, 4.5 pgs.*
VMEbus controller taps into 32-bit potential. *Gross, Ed, Interphase; Emery, Michael, Interphase; Computer Design, 01/01/86, pg 91, 6 pgs.*
VME Bus and Multibus II industrial I/O boards. *Harold, Peter, European Editor; EDN, 03/06/86, pg 191, 17 pgs.*

Video
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The drive to sharpen NTSC TV picture begins. *Weber, David M, Industrial & Consumer Editor; Electronics, 12/23/85, pg 59, 2 pgs.*

Virtual memory

70-bit processor chip will do complex decision making. *Staff; Electronics, 11/11/85, pg 39, 2 pgs.*

Vision systems

Applications proliferate as digital image processing enters mainstream design. *Preston, Craig, Data Translation; Molinari, Fred, Data Translation; Electronic Design, 03/06/86, pg 137, 6 pgs.*

Digital signal processing IC helps to shed new light on image processing applications. *Casey, Patrick E, Analog Devices; Simmers, Larry, Analog Devices; Electronic Design, 03/20/86, pg 135, 5.5 pgs.*

Image processors allow hardware reconfiguration to match applications. *Williams, Tom, Western Managing Editor; Computer Design, 02/15/86, pg 46, 1.5 pgs.*

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Machine vision finds a niche in automated inspection. *Shapiro, Sydney F, Managing Editor; Computer Design, 03/15/86, pg 46, 3.5 pgs.*

Machine vision inspection market still wide open. *Shapiro, Sydney F, Managing Editor; Computer Design, 04/15/86, pg 36, 3 pgs.*

Machine vision. *Allan, Roger, Associate Managing Editor; Electronic Design, 11/14/85, pg 106, 8 pgs.*

Voice-I/O equipment

Speech I/O products offer board-level solutions. *Cashen, Frank, Contributing Editor; Computer Design, 03/15/86, pg 36, 4.5 pgs.*

Speech processing: hearing better, talking more. *Rosenberg, Robert, Communications Editor; Electronics, 04/21/86, pg 26, 5 pgs.*

Voltage converters

CMOS curbs the appetite of power-hungry dc-dc converter chips. *Allen, Charlie, Maxim Integrated Products; Electronic Design, 11/14/85, pg 175, 5 pgs.*

W

Wire & cable

Custom cable assemblies can improve device reliability, save time and money. *Mosley, J D, Texas Editor; EDN, 02/20/86, pg 79, 4 pgs.*

EDITED BY TARLTON FLEMING

Test the latch-up tendency of CMOS devices

Harvey L Harman
Burroughs Corp, Paoli, PA

The inadvertent triggering of a parasitic SCR device can cause a latch-up condition that may incur excessive current flow and possibly destroy a CMOS chip. The test circuit of **Fig 1** lets you test a CMOS device's propensity to latch by subjecting the part to both ac and dc (positive and negative supply) latch conditions. Note, however, that the amplifier capability required to test this behavior has the potential to destroy the part: IC_1 can deliver 500 mA and can slew at 6000V/μsec.

To conduct a typical latch-up test, set V_{CC} to its maximum value, then separately subject each terminal of interest to a voltage V_{IN}, and slowly increase that voltage toward the V_{CC}+3V level. Latch-up will occur if the supply current I_{CC} exceeds the limit value set by potentiometer R_1. R_1 and the voltage regulator IC_2 limit the input current to regulator IC_3, which in turn limits current to the device under test (DUT). Setting R_1 to 12.5Ω, for example, allows 100 mA max into IC_3. Potentiometer R_2 lets you adjust the V_{CC} level. The component values shown provide a 1.25 to 6.25V range, suitable for testing HC and HCT CMOS devices. Regulator IC_4 provides a separate, adjustable pin voltage for application to the pins not under test.

You can also test for latch-up in the negative-supply direction by slowly decreasing V_{IN} from 0 to −3V, monitoring I_{CC} as before. Further, you can initiate ac latch-up conditions by applying 20-μsec, 2-kHz pulses at V_{IN}. Again, slowly increase the pulse amplitude toward the V_{CC}+3V level (or toward −3V) while monitoring I_{CC}. **EDN**

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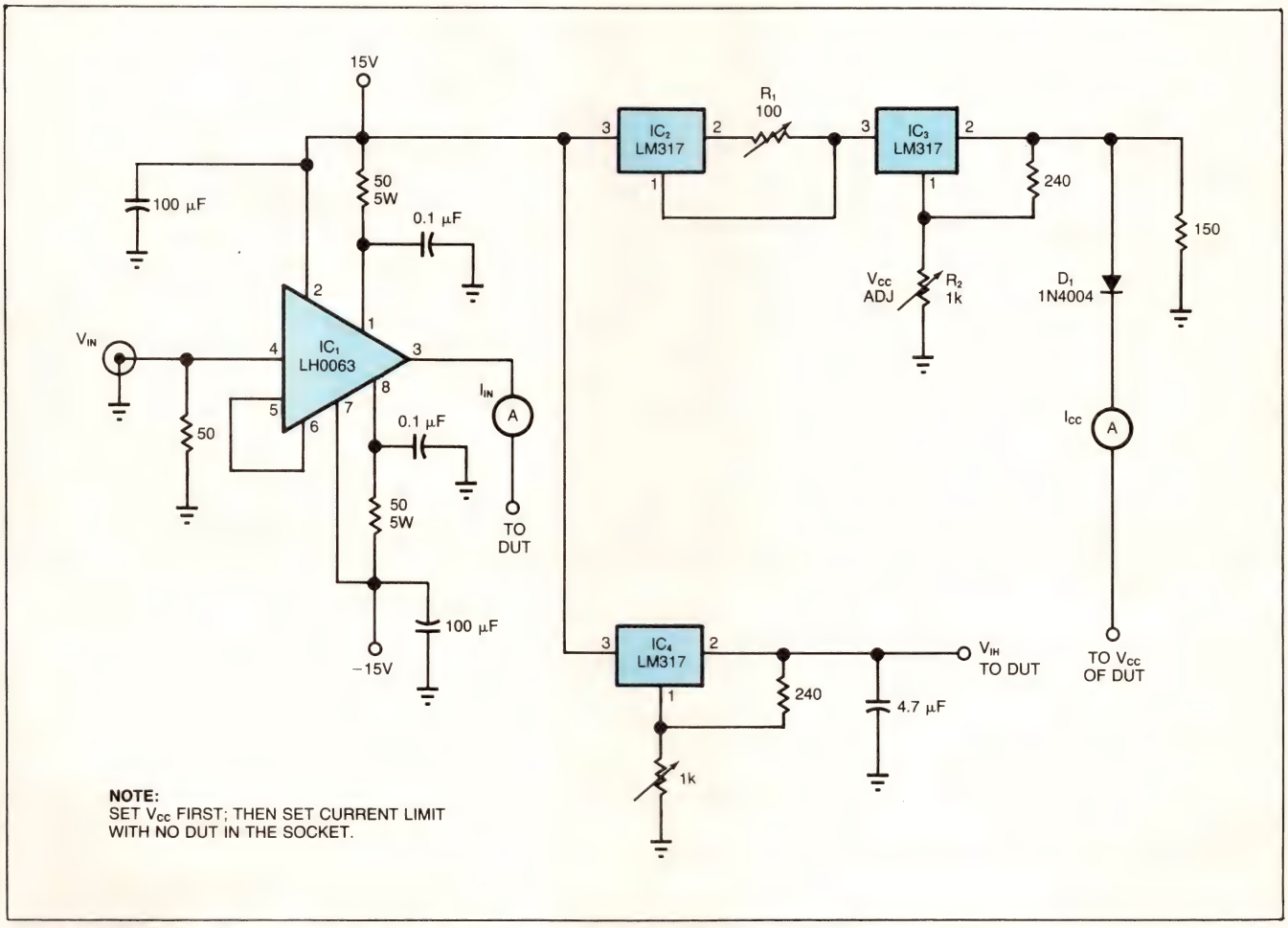

Fig 1—To test your CMOS devices for latch-up, *subject them to ac and dc latch conditions.*

Oscillator generates discrete sequence

T G Barnett
The London Hospital Medical College, London, UK

The swept-frequency oscillator of **Fig 1** offers an inexpensive source of discrete frequencies for use in testing digital circuits. In this configuration, the circuit generates an 80-sec sequence of eight frequencies, dwelling for 10 sec on each frequency. You can change the dwell time or the number of frequencies. Frequencies can range from 0.005 Hz to 1 MHz.

The programmable crystal oscillators (PXOs) IC_2 and IC_4 can each generate 57 frequencies in response to an 8-bit external code. IC_2 contains a 1-MHz crystal and produces a 0.05-Hz output. IC_4 contains a 600-kHz crystal; its output changes in response to the combined outputs of the 12-stage binary counter IC_3 (Q_1 and Q_2) and the PXO IC_2.

To generate more frequencies, you can use one or more of IC_3's outputs (Q_3, Q_4, Q_5) to drive one or more of IC_4's inputs (P_4, P_5, P_6). Similarly, you can rewire IC_2 or drive it with other logic to control the duration of each frequency. IC_1, a monostable multivibrator, provides a system reset. It initiates the sequence shown, beginning at 60 Hz, in response to a positive pulse. **EDN**

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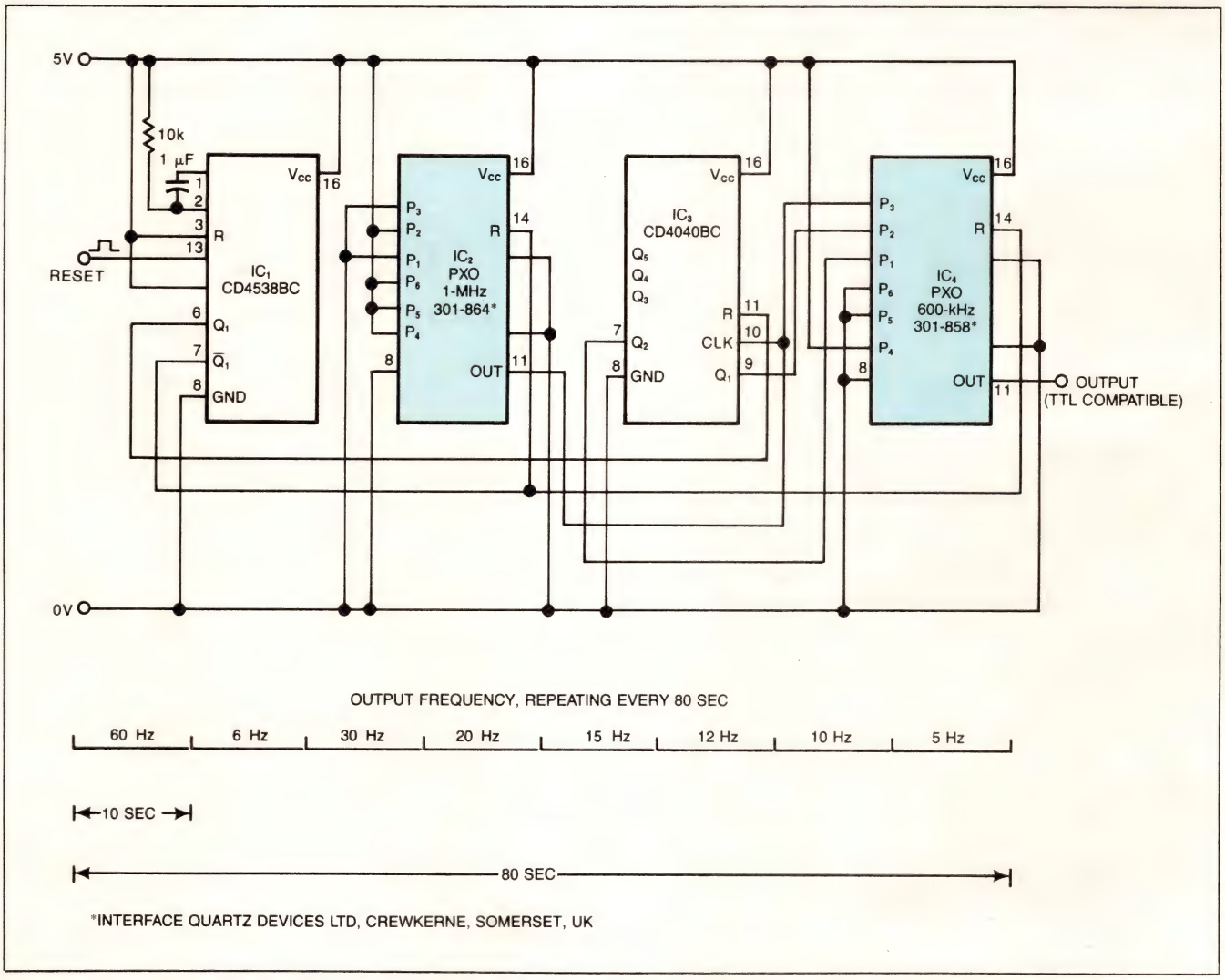
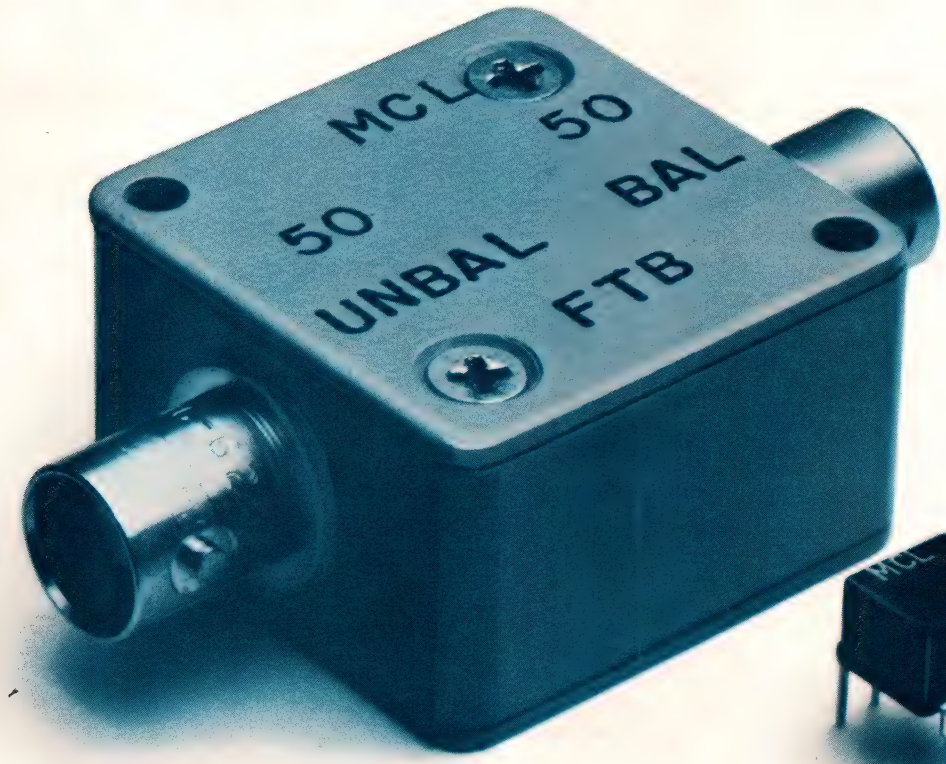
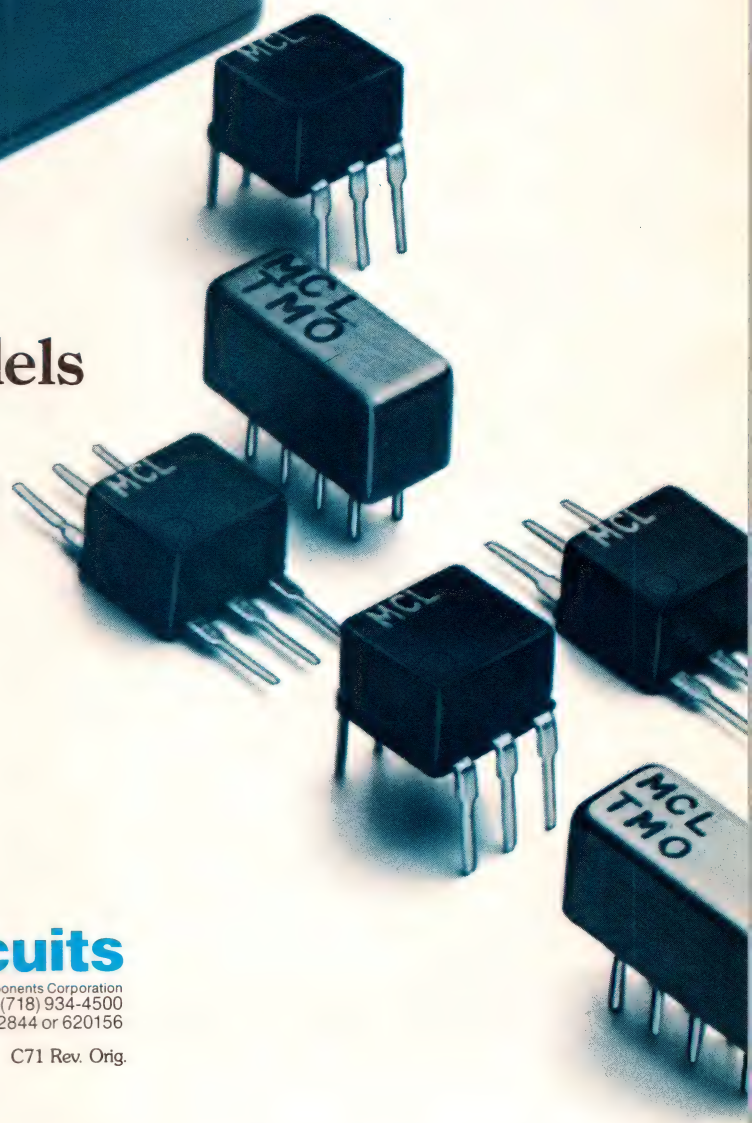


***Fig 1—A swept-frequency oscillator** uses programmable-frequency devices IC_2 and IC_4 to produce a sequence of discrete-frequency square waves.*

RF transformers





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CIRCLE NO 159

Chopper amp provides low-offset filter

Kevin Hoskins
National Semiconductor, Santa Clara, CA

The low offset of a chopper-stabilized, autozeroed op amp gives it an advantage over conventional op amps when you use it as an antialiasing filter in a data-acquisition system. Nonetheless, the clock signal driving the amplifier's chopper circuit produces glitches in the amplifier's output; if the system's A/D converter encounters these glitches when sampling, significant errors may result.

Fig 1 shows a system that circumvents the glitch problem by synchronizing the converter with the amplifier's chopper frequency. IC_1 is a chopper-stabilized op amp used in a Sallen-Key antialiasing filter (in this case, a second-order, lowpass, Butterworth filter). The filter's output glitches represent 25-LSB errors to IC_3, which is a 10-bit A/D converter with a 5V reference. The circuit derives the filter's clock signal from the converter's $\overline{INTR}$ (end of conversion) signal, which ensures that the glitches won't occur during a conversion interval. You should configure the ripple counter (IC_2) to divide by a factor that provides a clock frequency between 200 and 400 Hz.

Components R_1, R_2, C_1, and C_2 set the filter's −3-dB cutoff frequency f_C. Let $R_1=R_2=R$. Then, $C_1=1.414/(6.283Rf_C)$ and $C_2=C_1/2$. Setting the filter cutoff frequency at one-fifth the converter's sample rate is reasonable for low-bandwidth input signals; higher bandwidths may require either a higher-order filter (easily realized by cascading second-order sections) or a lower filter cutoff, and a S/H amplifier. **EDN**

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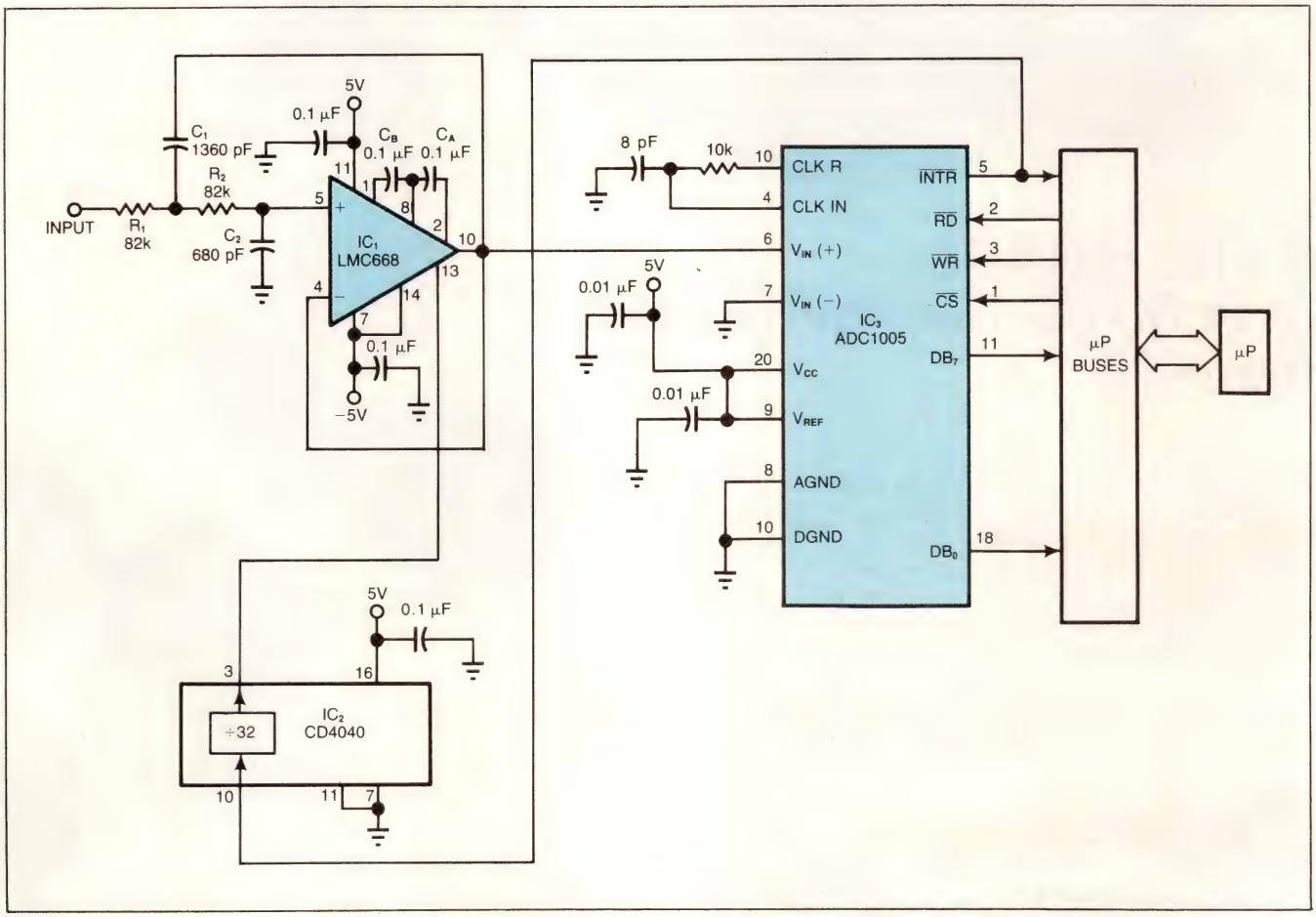

Fig 1—A chopper-stabilized amplifier, IC_1, *forms a low-offset antialiasing filter. The circuit derives the chopper amp's clock signal from the converter's end-of-conversion signal, which lets the converter avoid output glitches from the chopper amp.*

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CIRCLE NO 58

Program computes log magnitude and phase

Thomas Hack
Master Designers Inc, Colorado Springs, CO

Written in Commodore 64 Basic, the program in **Listing 1** gives you the log magnitude (in dB) and the phase (in degrees) for any generalized transfer function of the form

$$H(s) = \frac{A_0 + A_1 s^1 + \ldots A_n s^n}{B_0 + B_1 s^1 + \ldots B_m s^m},$$

where s is the complex-frequency variable. You can use this program for evaluating new filter designs.

As an example, the program in **Listing 2** provides the inputs required to describe a third-order, elliptic, lowpass filter with a 3-kHz passband, a 50% reflection coefficient, and a 25° modular angle (an elliptic-filter term). After execution, the program sends its output to the computer's printer port. This data (**Listing 3,** see pg 209) tells you that the filter's passband ripple is approximately 1.25 dB and that its stopband attenuation is −40.5 dB. **EDN**

LISTING 2

```
TRANSFER FUNCTION EVALUATION
ORDER OF NUMERATOR? 2
A( 0 )=? 3.118E12
A( 1 )=? 0
A( 2 )=? 1.204E3
ORDER OF DENOMINATOR? 3
B( 0 )=? 3.118E12
B( 1 )=? 4.153E3
B( 2 )=? 1.692E4
B( 3 )=? 1
START FREQ (HZ)? 0
END FREQ (HZ)? 9600
STEP FREQ (HZ)? 200
```

To Vote For This Design, Circle No 746

LISTING 1

```
10 PRINT "TRANSFER FUNCTION EVALUATION"
20 REM INITIALIZE VARIABLES
30 CLR
40 DIM A(100,1),N(1),N$(1),P$(1),RE(1),IM(1),PH(1)
50 N$(0)="NUMERATOR"
60 N$(1)="DENOMINATOR"
70 P$(0)="A("
80 P$(1)="B("
85 C=1/LOG(10):REM LN/LOG CONV FACTOR
86 D=57.29577951:REM RAD/DEG CONV FACTOR
87 LM=50:REM MAXIMUM LINES/PAGE
88 OPEN 4,4
90 FOR X=0 TO 1
100 PRINT "ORDER OF ";N$(X);
110 INPUT N(X)
120 IF N(X)<0 THEN 100
130 FOR Y=0 TO N(X)
140 PRINT P$(X);Y;")=";
150 REM INPUT COEFFICIENTS
160 INPUT A(Y,X)
170 NEXT Y
180 NEXT X
190 INPUT "START FREQ (HZ)";F1
200 IF F1<0 THEN 190
210 INPUT "END FREQ (HZ)";F2
220 IF F2<F1 THEN 210
230 INPUT "STEP FREQ (HZ)";F3
```

```
240 IF F3<=0 THEN 230
245 F2=F2+.1*F3
246 GOSUB 650
250 FOR F=F1 TO F2 STEP F3
260 REM INITIALIZE FOR NEW FREQUENCY
270 K=6.283185308*F
280 RE(0)=0
290 IM(0)=0
300 RE(1)=0
310 IM(1)=0
320 FOR X=0 TO 1
330 Z=0
340 W=1
350 FOR Y=0 TO N(X)
360 IF Z=0 THEN RE(X)=RE(X)+A(Y,X)*W
370 IF Z=1 THEN IM(X)=IM(X)+A(Y,X)*W
380 IF Z=2 THEN RE(X)=RE(X)-A(Y,X)*W
390 IF Z=3 THEN IM(X)=IM(X)-A(Y,X)*W
400 Z=Z+1
410 IF Z>3.5 THEN Z=0
420 W=W*K
430 NEXT Y
440 NEXT X
450 DT=RE(1)*RE(1)+IM(1)*IM(1)
460 DB=10*C*LOG((RE(0)*RE(0)+IM(0)*IM(0))/DT)
470 REM COMPUTE OVERALL RE AND IM PARTS
480 RT=(RE(0)*RE(1)+IM(0)*IM(1))/DT
490 IT=(IM(0)*RE(1)-RE(0)*IM(1))/DT
500 PH=D*ATN(IT/RT)
510 IF RT<0 AND IT>=0 THEN PH=PH+180
520 IF RT<0 AND IT<0  THEN PH=PH-180
521 PA$="                "
522 F$=STR$(F)+PA$
523 F$=LEFT$(F$,15)
524 DB$=STR$(DB)+PA$
525 DB$=LEFT$(DB$,15)
526 PH$=STR$(PH)+PA$
527 PH$=LEFT$(PH$,15)
530 PRINT#4,F$;" ";DB$;" ";PH$
535 LC=LC+1
536 IF LC>=LM THEN GOSUB 620
540 NEXT F
550 INPUT "SAME TRANSFER FUNCTION? (Y)";Z$
560 Z$=LEFT$(Z$,1)
570 IF Z$<>"N" THEN 190
580 INPUT "QUIT? (N)";Y$
590 Y$=LEFT$(Y$,1)
600 IF Y$<>"Y" THEN 10
609 CLOSE 4
610 STOP
620 PRINT "LOAD NEXT PAGE AND THEN PRESS ANY KEY TO CONTINUE PRINTING"
630 GET X$
640 IF X$="" THEN 630
650 PRINT#4,"FREQUENCY (HZ)   DECIBELS        DEGREES"
655 LC=1
660 RETURN

READY.
```

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Anritsu, the world leader in fiber optics measuring instruments, offers you its all-new, portable MW910A Optical Time Domain Reflectometer. This newest OTDR has the same pedigree as our popular MW98A, the best selling OTDR in the world. And Dual Band and portability make the MW910A no less special. Just take a look at the stats:

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CIRCLE NO 74

LISTING 3

FREQUENCY (HZ)	DECIBELS	DEGREES			
0	0	0	5000	-21.3401827	127.097772
200	-.0516809483	-9.5467617	5200	-23.0464281	125.042137
400	-.196962232	-18.8480265	5400	-24.7283018	123.234412
600	-.409594752	-27.7207364	5600	-26.3994772	121.628999
800	-.653984143	-36.0802568	5800	-28.0741286	120.191169
1000	-.892479748	-43.9442207	6000	-29.7677024	118.39398
1200	-1.09011364	-51.4179619	6200	-31.4979516	117.716189
1400	-1.21651191	-58.6796135	6400	-33.2864338	116.6408
1600	-1.24625687	-65.9774441	6600	-35.1608434	115.654031
1800	-1.1596461	-73.6463229	6800	-37.1589277	114.744576
2000	-.946704405	-82.147123	7000	-39.3356133	113.903059
2200	-.619906595	-92.1248526	7200	-41.7772828	113.12163
2400	-.246053208	-104.438087	7400	-44.634205	112.393658
2600	-6.04649186E-03	-119.957322	7600	-48.2088722	111.713496
2800	-.23372916	-138.705771	7800	-53.2809506	111.076301
3000	-1.25079436	-158.654817	8000	-63.4727922	110.477892
3200	-3.02777849	-176.586788	8200	-63.9296725	-70.0853632
3400	-5.22355481	169.210057	8400	-54.9990189	-70.616639
3600	-7.52786681	158.524055	8600	-51.1224526	-71.118722
3800	-9.78432703	150.485697	8800	-48.7394121	-71.5940714
4000	-11.9395166	144.308593	9000	-47.0793397	-72.044867
4200	-13.9862069	139.433687	9200	-45.8441699	-72.4730488
4400	-15.9343067	135.487126	9400	-44.8871085	-72.8803499
4600	-17.798892	132.219707	9600	-44.125078	-73.2683246
4800	-19.5957878	129.462402			

MOSFET circuits yield higher BV_{DSS}

Tosh Mizuno
Dalmo Victor Co, Belmont, CA

You can create a composite MOSFET whose BV_{DSS} is double that of a single MOSFET by combining two devices with a diode and two resistors (**Fig 1**). Even though you can buy an MTP1N100 MOSFET from Motorola that has a 1000V minimum BV_{DSS}, you may need a higher value for use in a gated image intensifier, for example, or a TWT grid modulator.

With a voltage V_{DD} between the composite drain and source, $V_{G2}=\frac{1}{2}V_{DD}$. Therefore, the voltage at P equals $\frac{1}{2}V_{DD}$ minus Q_2's gate-source threshold voltage $V_{GS(TH)}$, but $V_P \approx \frac{1}{2}V_{DD}$ for large V_{DD}. The 12V zener diode D_1 ensures that the gate of Q_2 is sufficiently positive for Q_2 to remain in saturation under all conditions. Thus, Q_2's on-resistance remains low, and the composite

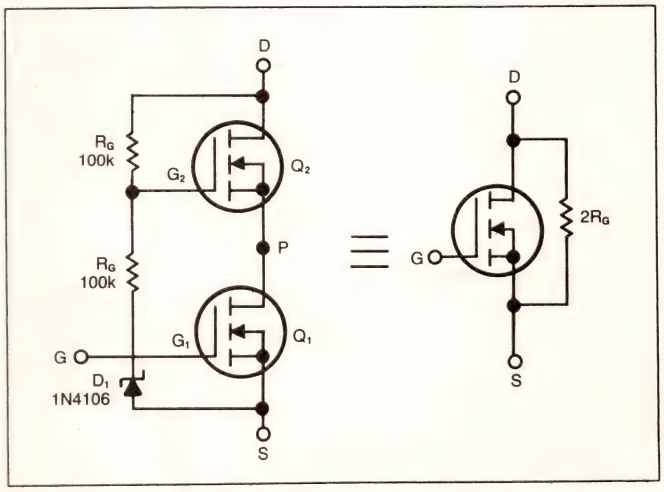

Fig 1—Double a MOSFET's BV_{DSS} *by connecting two units in series. This composite device behaves as shown in the equivalent diagram.*

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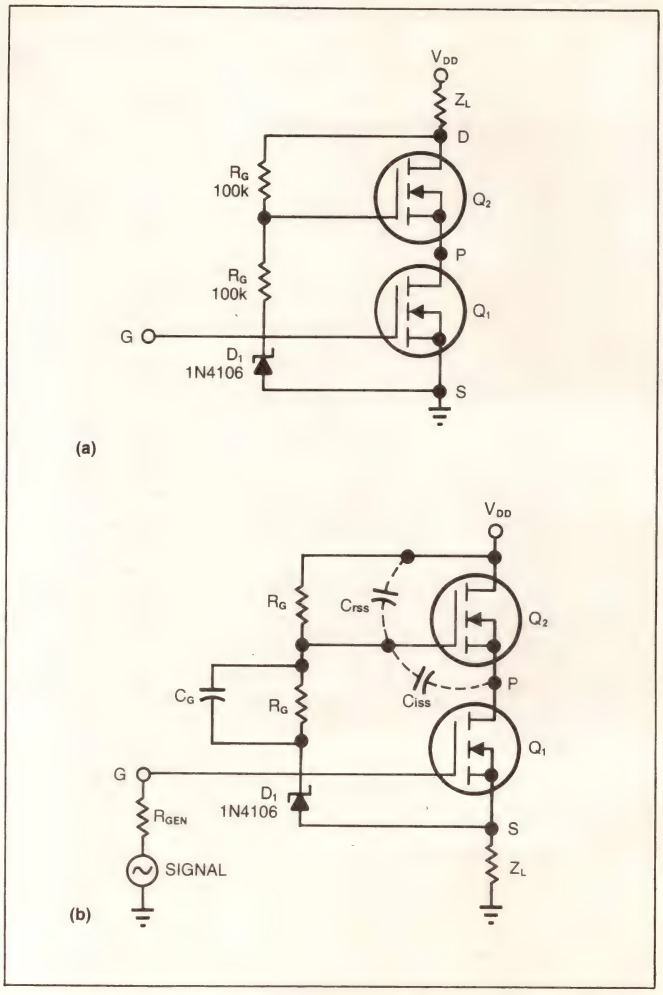

Fig 2—You can use the composite MOSFET *in conventional high-V_{DD} applications such as common-source* ***(a)*** *and source-follower* ***(b)*** *connections.*

MOSFET's electrical characteristics depend only on the characteristics of Q_1.

Typical applications of this composite MOSFET include the common-source connection **(Fig 2a)** and the source-follower connection **(Fig 2b).** For the source follower, you must add capacitor C_G to compensate for the gate capacitance of Q_2. Because this gate capacitance doesn't generally equal the sum of C_{rss} and C_{iss}, you must experiment to determine the required compensation value. (For example, you might want to select a capacitor that achieves less than −90° of phase shift at the highest signal frequency of interest.) **EDN**

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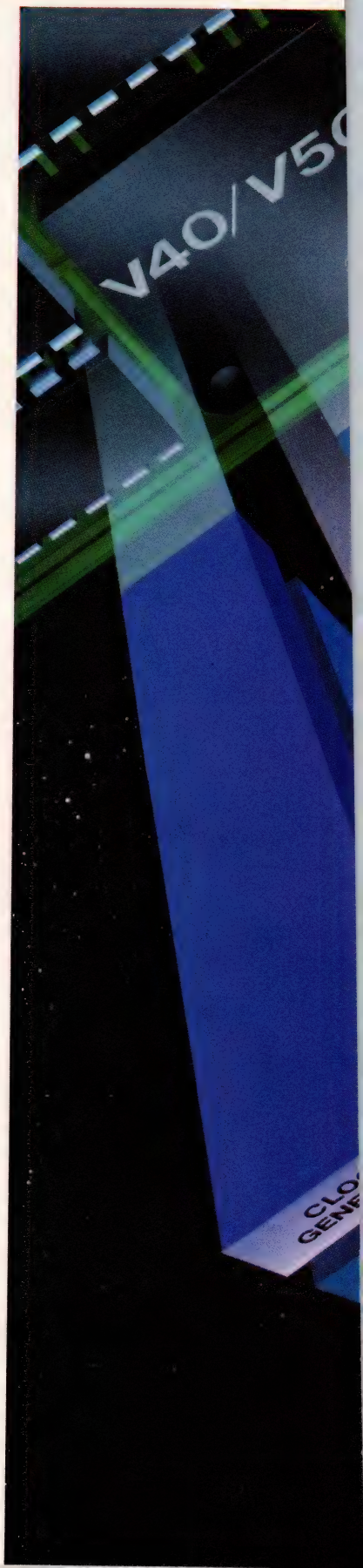

Microprocessor Design Criteria and Choices

	8088/86 NMOS MPU/ peripherals	80C88/80C86 CMOS MPU/ peripherals	80186 NMOS high-integration	V40/V50 CMOS high-integration
Reduce Component Cost	Yes	No	Yes	Yes
Save PC Board Space	No	No	Yes	Yes
Increase Functionality	No	No	No	Yes
Reduce Power/Cooling Requirements	No	Yes	No	Yes
Increase Reliability	No	No	No	Yes
Shorten Design Cycle	No	No	Yes	Yes

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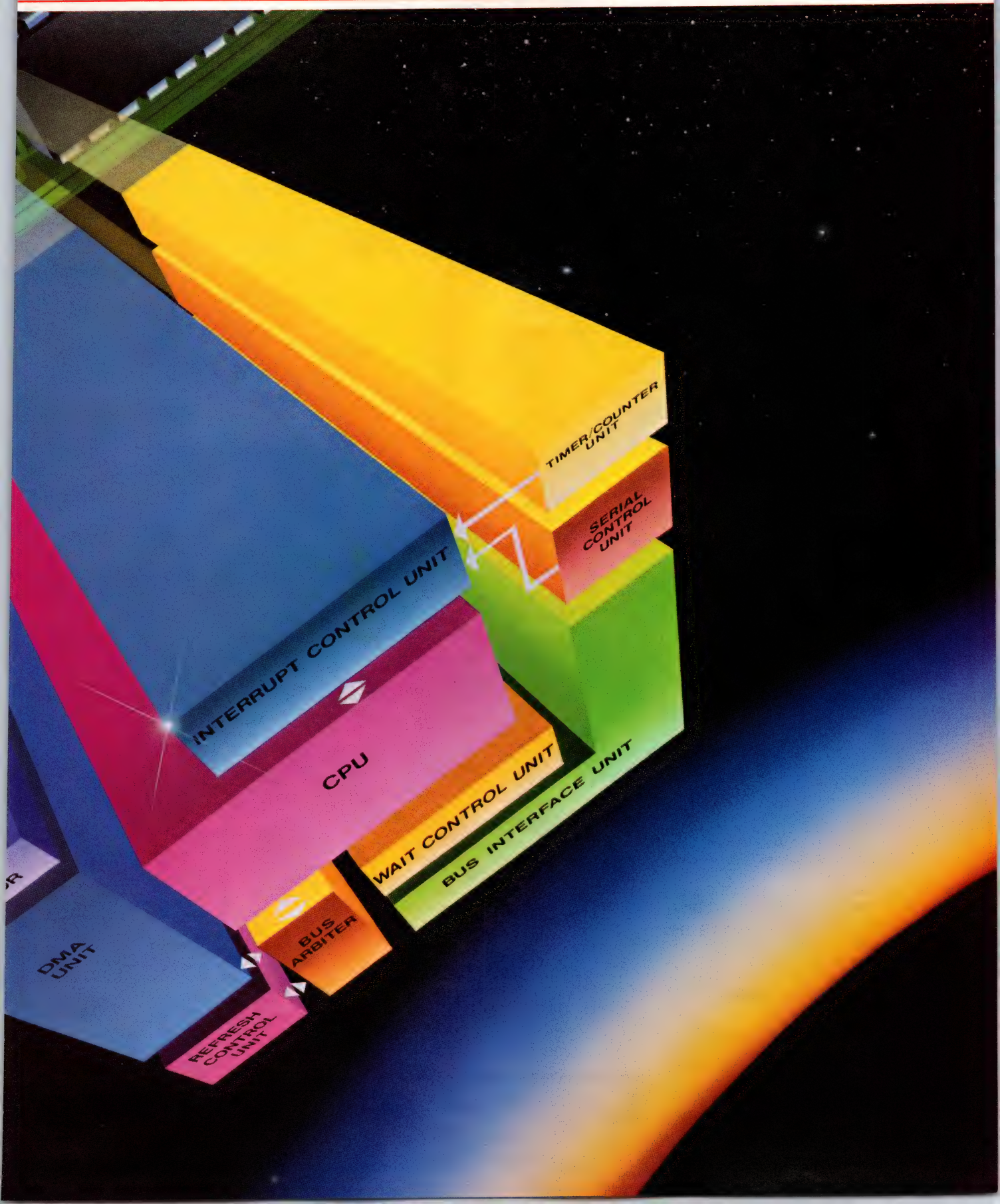

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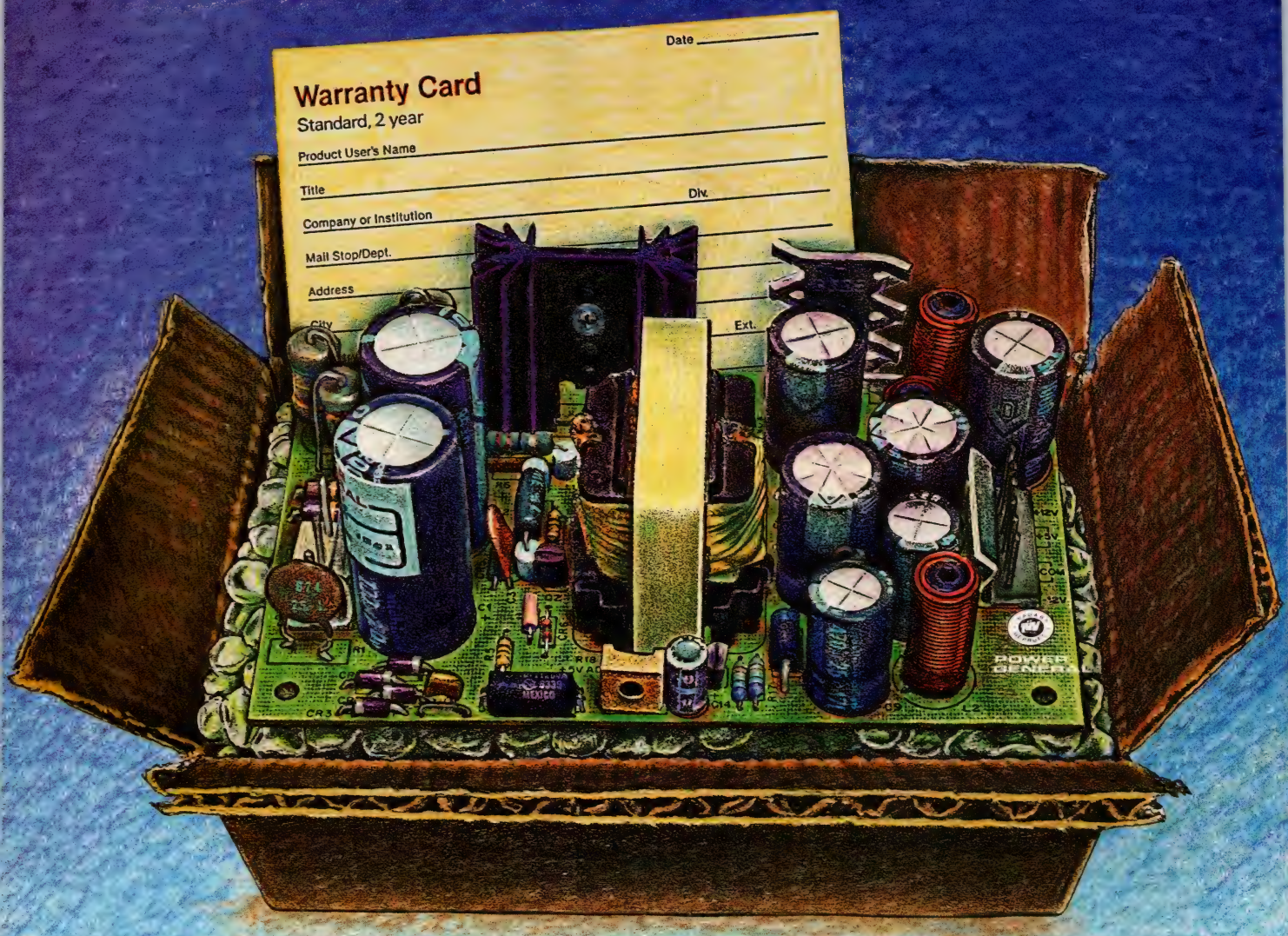

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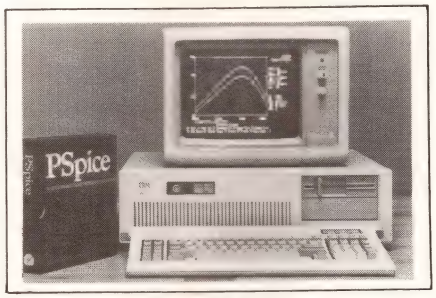
PLD PACKAGE UPGRADE

- *Supports 23 additional devices*
- *Adds state-machine syntax*

CUPL version 2.1 for configuring programmable logic devices includes the addition of state-machine syntax, a choice of four logic-minimization algorithms, and an enhanced deMorgan expansion capability; its library supports 23 additional devices, including registered-input devices from Texas Instruments; 20- and 24-pin CMOS GAL EEPLDs from Lattice; Altera's EP6000; one FPLA from Signetics and one from TI; CMOS EPLDs from Panatech, Ricoh, and VTI; and ECL PALs from MMI, National, and TI. The library comprises devices from 15 manufacturers; it contains over 100 PLD architectures. The program's logic-minimization algorithms reduce the frequency of errors that arise when you use negative expressions and invoke a deMorgan expansion. The program is available in VMS, Unix, and MS-DOS versions. $995 for MS-DOS version.

Personal CAD Systems Inc, 1290 Parkmoor Ave, San Jose, CA 95126. Phone (408) 971-1300.

Circle No 351



DEVICE LIBRARIES

- *Accepts data-sheet inputs*
- *Runs on IBM PC*

Users of the PSpice circuit simulator can use the Parts option to create model libraries or bipolar transistors, diodes, op amps, and voltage comparators. To create these models, you must enter data-sheet information from your component manufacturer. You can generate best- and worst-case models (which take account of variations in device characteristics and in operating temperatures). The interactive option leads you through the input process and presents device curves of operating parameters. Hard copies are available from dot-matrix printers and pen plotters. The program runs on the IBM PC. $450.

MicroSim Corp, 23175 La Cadena Dr, Laguna Hills, CA 92653. Phone (800) 826-8603; in CA, (714) 770-3022.

Circle No 352

FAULT SIMULATOR

- *Handles 64,000 modeling elements*
- *Expandable to 1M elements*

Based on the same technology as the vendor's Mach 1000 logic accelerator, the Mach 1000F fault accelerator can perform a fault simulation of a design that contains as many as 64,000 modeling elements; optional expansion modules permit simulation of as many as one million modeling elements. The accelerator implements a concurrent fault-simulation algorithm in hardware. According to the vendor, the hardware accelerator exceeds the speed of a VAX by about a factor of 100. Ten custom-VLSI circuits enable the fault simulator to achieve this speed. Furthermore, the concurrent algorithm, which eliminates the need to retain data relating to an identified fault, increases the speed of the simulator with respect to serial fault simulators. Both fault and logic simulation functions, $200,000; field upgrade of the Mach 1000, $80,000.

Silicon Solutions, 1380 Willow Rd, Menlo Park, CA 94025. Phone (415) 321-8574.

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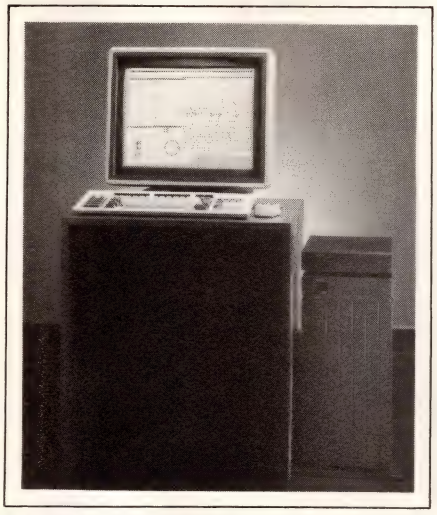

WORKSTATION

- *Employs 8-MHz, 16-bit slice*
- *Handles board-design tasks*

The 6085 Expert Designer workstation is compatible with the company's 8000 and 6080 systems; an option provides IBM PC emulation. The workstation runs software for automating pc-board design and layout, logic design and simulation, mechanical drafting, and engineering publishing. The 6085 is based on a 16-bit-slice Mesa processor that executes 48-bit-wide microinstructions at 8 MHz. The PC option, which is a pc board that uses Intel's 16-bit 80186 μP, enables the 6085 to operate two processors in parallel. The PC emulator uses the main memory—128 to 640k bytes of contiguous memory assigned in 128k-byte increments. When the option is idle, all main memory is available to the workstation applications. The workstation offers either a 15- or 19-in. monochrome bit-mapped display. The standard 6085 includes 40M-byte, 5¼-in. hard-disk drive; a 500k-byte IBM-compatible 5¼-in. floppy-disk drive; 1.1M bytes of main memory (expandable to 3.7M bytes); and a 2-button optical mouse. A 20M- or 80M-byte hard-disk drive and an Ethernet interface are optional. 6085, $7000 to $12,000; pc-board design software, $32,000; schematic entry, $6500; logic simulation and hardware-description language, $14,000; PC-emulation board, $750; MS-DOS operating system, $125.

Xerox Corp, EIS Unit, 2945 Oakmead Village Ct, Santa Clara, CA 95051. Phone (408) 988-2800.

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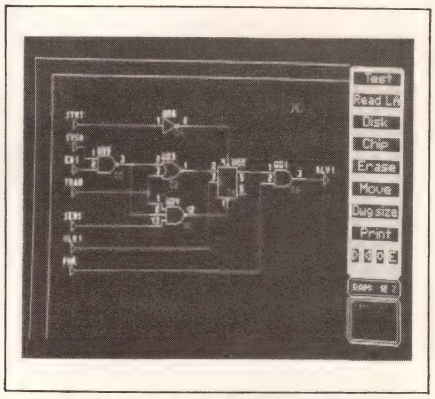

FAULT DETECTOR

- *For digital pc boards*
- *Requires analyzer and PC*

Fast (functional automated simulation and troubleshooting) automatically isolates faults on digital pc boards. This software package requires a logic analyzer and any member of the IBM PC family that includes an RS-232C or IEEE-488 interface, at least 512k bytes of RAM, and (preferably) a hard disk. To operate the system, you connect the logic analyzer's probes to targeted points on the circuit board; the PC's monitor displays timing signals. The package then compares the timing signals with the expected results generated by the company's Slav (schematic logic analyzer and verifier) logic simulator. Using a color monitor, the program identifies defective ICs, short or open lines, and points stuck in the high or low state on the schematic of the logic circuit under test. You can use a single color monitor and alternately display timing signals and the schematic. No special board conditioning, such as grounding or presetting inputs, is necessary. Analysis can start from an unknown initial condition or from any operational cycle. Moreover, you don't need to disconnect feedback loops. IC fami-

Continued on pg 221

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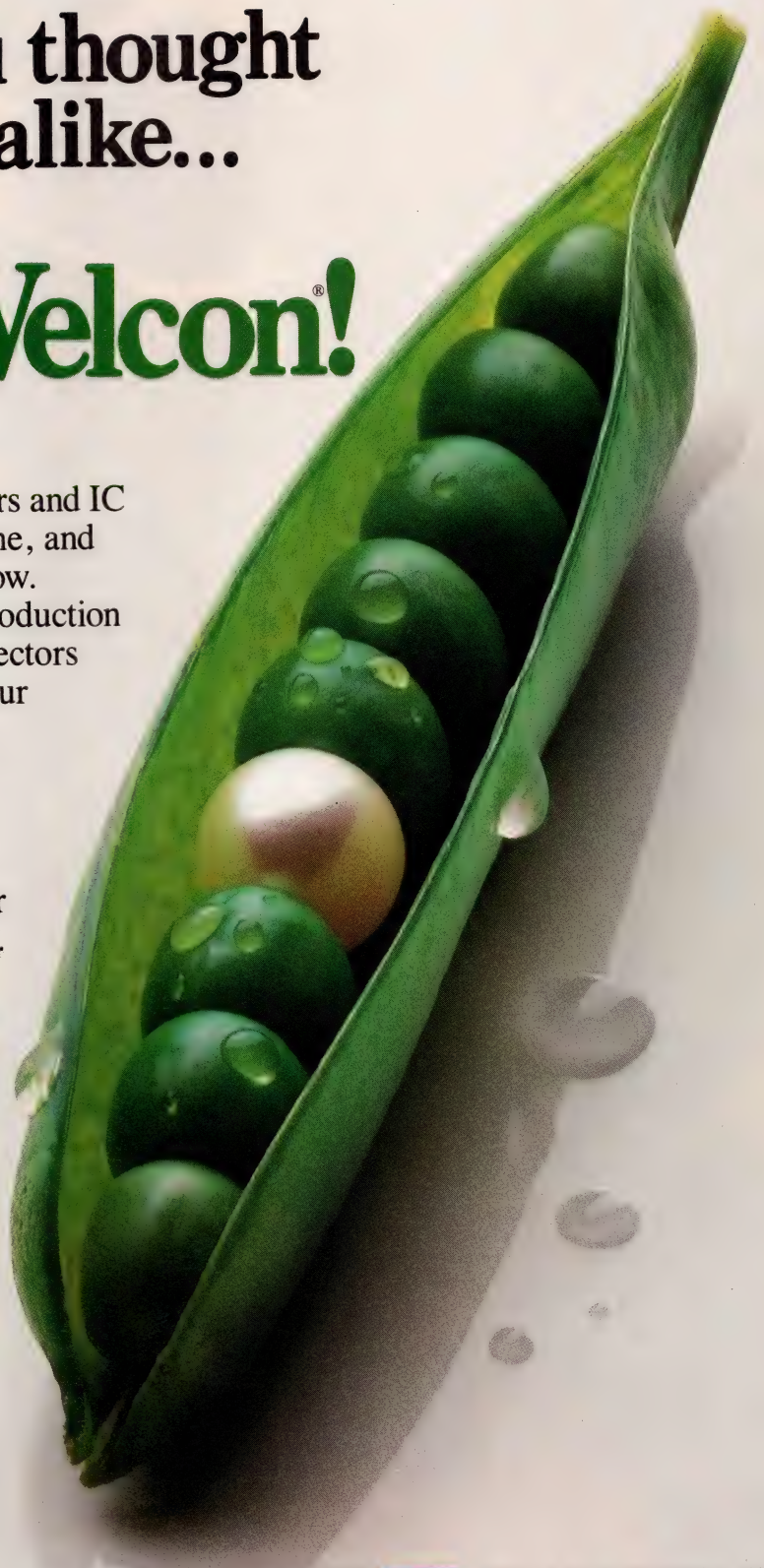

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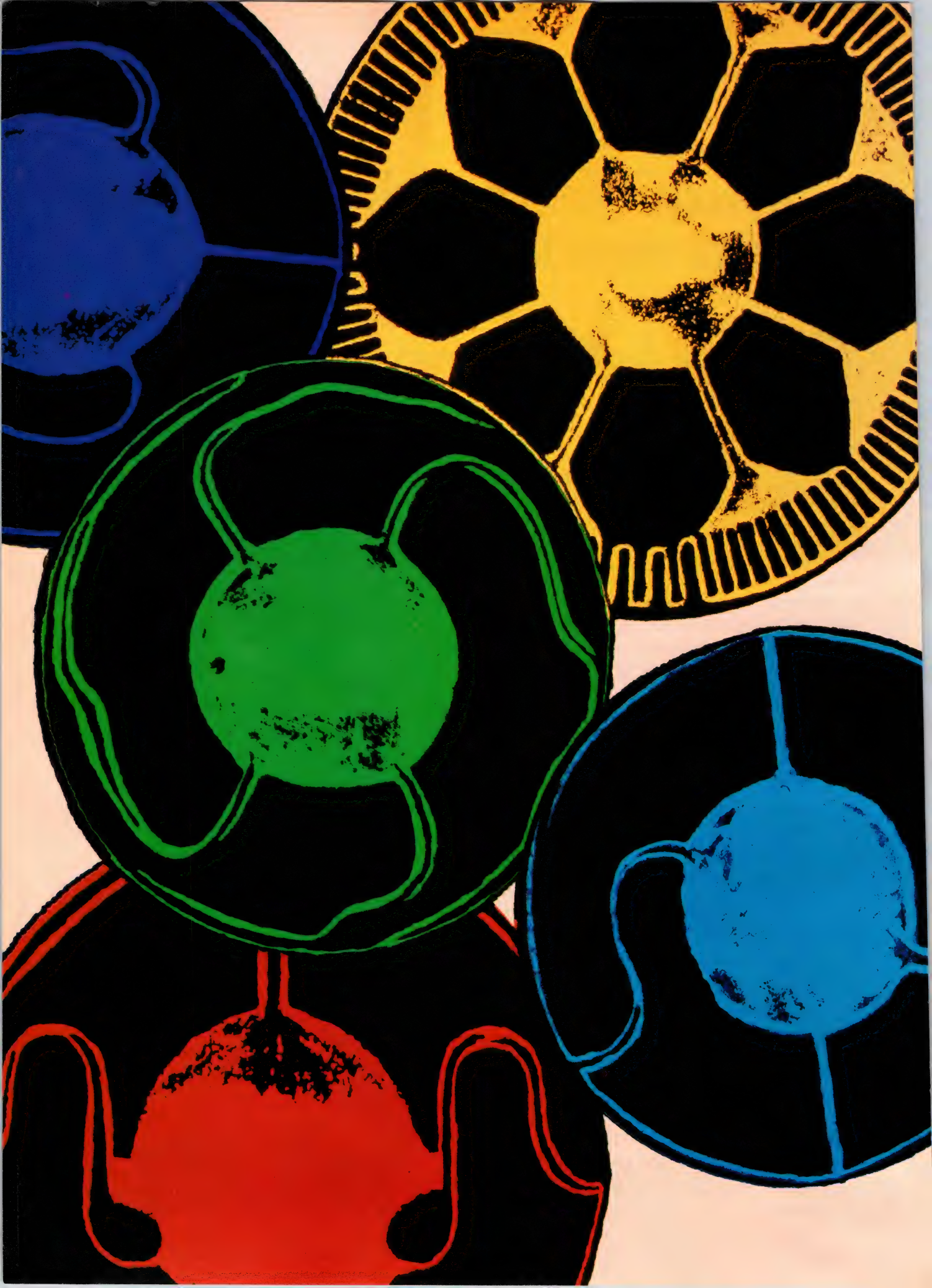

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Characteristics (Typical)	H-18B	H-23CV	H-30CH
Br (G)	8,500	9,700	10,600
bHc (Oe)	8,300	8,500	9,000
(BH) max. (MG•Oe)	17	22	26

Ferrite Magnets

Characteristics (Typical)	YBM-2BB	YBM-2BE	YBM-2BF
Br (G)	4,200	3,900	3,700
Hc (Oe)	2,800	3,700	3,500
iHc (Oe)	—	4,000	5,000

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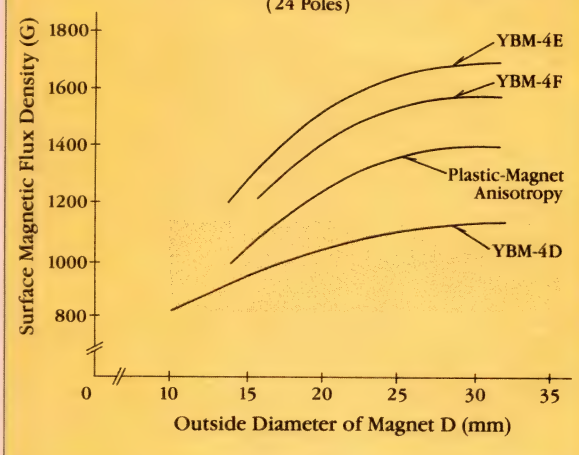
(24 Poles)



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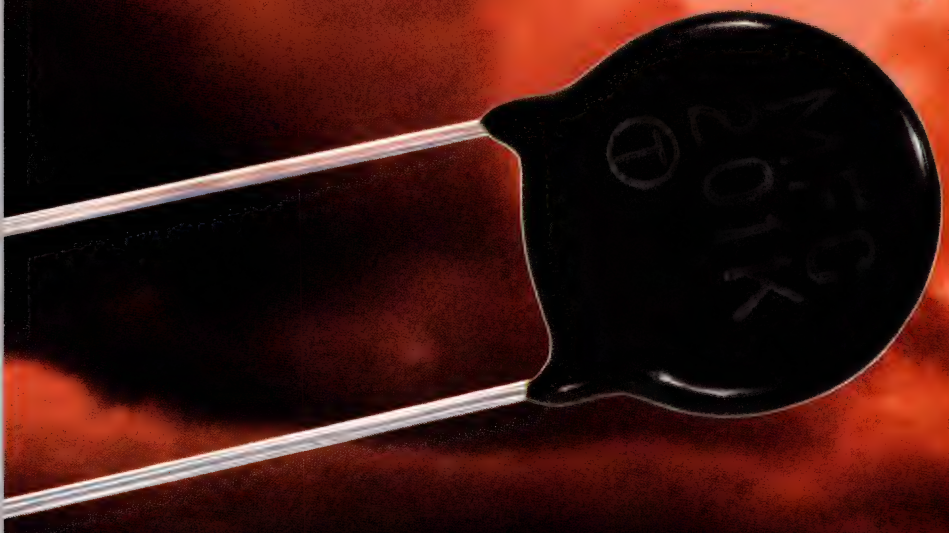
Other Offices: Border Region (517) 427-5151, New England Region (603) 882-5204, Empire Region (201) 263-8675, Southeast Region (704) 525-4136, East Central Region (216) 871-8993, Central Region (312) 934-0707, South Central Region (713) 931-0875, Northwest Region (408) 745-7224, Southwest Region (714) 756-8594, Western Region (714) 549-2945

Systems Magnetic Company, Inc.
2837 Coronado Street, Anaheim, California 92806, U.S.A. Phone: (714) 632-8400 Telex: (910) 591-1191

CIRCLE NO 78

MFC VARISTOR...THE ULTIMATE protection

Taiyo Yuden's "MFC" noise and spike eliminator.



MFC TYPES AVAILABLE

HO4D

HO6D

O5D

SZ

O8D

14D

Various UL-recognized part numbers.

It's a capacitor and a varistor in one...a single super-component that eliminates degrading noise and absorbs destructive voltage surges. Talk about positive/negative protection!...Now a single component from Taiyo Yuden..."Multi-Function Ceramic" does it all...by providing in a single component, the same protection of a conventional capacitor and a zinc-oxide varistor, plus MFC's Self Reset Characteristic means no deterioration in IR even after repeated surges...Because of its high energy, surge resisting capacities, this remarkable new "MFC" responds quickly to rapidly rising voltage transients, assuring no delay in input-line protection...no matter how steep the voltage surges. Because of its capacitance by-pass effect, it absorbs all high frequency noise below the varistor level. That means you can expect trouble-free performance and less equipment downtime! Talk about broad applications!...Our exceptionally efficient "MFC" will safeguard your sensitive AC or DC circuits whether you're in telecommunications, telephones, computers, computer peripherals, automobiles, home appliances, industrial equipment, or Medical electronics...no matter what you make from power supplies to microwave ovens we'll help you make things better right down the line! Talk about choice!...You've got it in our H-Type miniaturized configurations that's ideal for automatic insertion on circuit boards that require upgraded noise margins and protection against static electricity, our N-Type configurations were developed to protect machinery from lightning and noise, as well as protecting semiconductor parts...either way, you can select from a wide variety of products to match your anticipated levels and manufacturing operations. "MFC" average varistor voltage ranges from 20 volts to 610 volts. Surge withstand capabilities extend from 0.1 joules to 8.0 joules. Many UL-recognized part numbers are included and every "MFC" offers superior temperature and humidity characteristics...competitive priced!

For more detail, samples and prices of these super-components, write or call:

TAIYO YUDEN (U.S.A.) INC.

714 West Algonquin Road • Arlington Heights, IL 60005

Tel: 1-312- 364-6104 • Telex: 910-687-0378 TAYO U.S.A. ARHT

CIRCLE NO 97

lies covered by the package include 5400/7400, CMOS 4000, 100K and 10K ECL, RAMs, ROMs, PLDs, and gate arrays. $2500.

Aldec, 3525 Old Conejo Rd, #111, Newbury Park, CA 91320. Phone (805) 499-6867.

Circle No 355

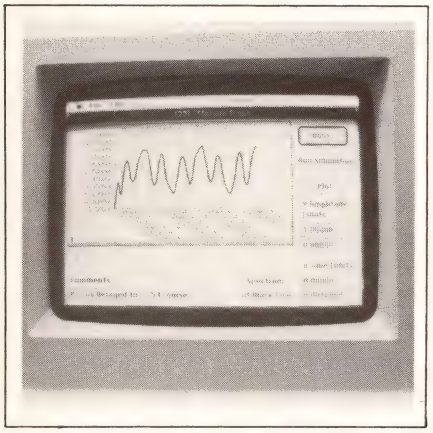
FILTER DESIGN

- *Designs 7th order filters*
- *Accepts graphical inputs*

RF Notes No 3 Volume 2 is a program that solves RF design problems. It designs lowpass, highpass, and bandpass Bessel-response filters (to the 7th order). Inputs are in graphical (response curve) form. Outputs are in schematic-diagram form and include circuit constants. Predicted response curves are available; you can check individual response points. The program runs on the IBM PC, PC/XT, PC/AT, and PCjr (enhanced). The personal computer must run DOS version 2.1 or higher and contain 128k bytes of RAM and a graphics card. $85.

Etron RF Enterprises, Box 4042, Diamond Bar, CA 91765. Phone (714) 594-8741.

Circle No 356



CIRCUIT SIMULATOR

- *Runs on Macintosh*
- *Simulates many functional blocks*

Designscope lets you develop electronic block diagrams, assign parameters to various blocks, and simulate circuits. The program runs on Apple's Macintosh computer. You can alter component parameters in a window on your computer and rerun your simulation. The list of component blocks available includes amplifiers, comparators, filters, phase-locked loops, voltage-controlled oscillators, analog switches, voltage sources, intergrators, differentiators, rectifiers, log-exponential amplifiers, multipliers, peak detectors, S/H ICs, delay lines, noise generators, clippers, ORs, NORs, NANDs, flip-flops, frequency dividers, one shots, transient generators, and output plotters. $249.95.

Brainpower Inc, 24009 Ventura Blvd, Suite 250, Calabasas, CA 91302. Phone (818) 884-6911.

Circle No 357

EPLD CAE PACKAGES

- *Run on company's programmer*
- *Handle CMOS PLDs*

Two software packages, Altsoft and Latsoft, let you program Altera's, Intel's, and Lattice's CMOS EPLDs. The software provides an interface to the company's VDS 160 serial I/O memory and logic programmer. Altsoft programs Altera and Intel's devices, which are CMOS UV-erasable PLDs that feature equivalent gate counts of 300 to 1200. Latsoft supports Lattice's GAL16V8, a CMOS EEPLD that you can program to be functionally equivalent to any of 21 20-pin PLDs. Altsoft, $400; Latsoft, $350.

Valley Data Sciences, 2426 Charleston Rd, Mountain View, CA 94043. Phone (415) 968-2900. TLX 4993461.

Circle No 358

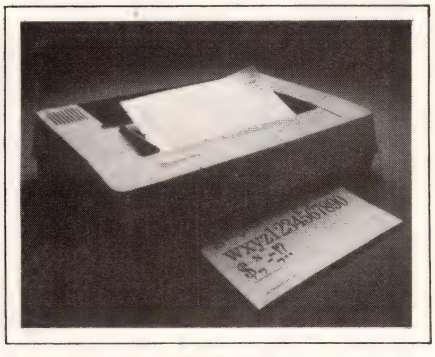
INK-JET PRINTER

- *1000 distinct color shades*
- *Resolution near 300 dots/in.*

Generating color images that approach photographic quality, the Chromajet 4000 ink-jet printer uses a 4-color ink array, a rotating drum, and a belt-driven head transport to produce a palette of 1000 distinct color shades for images with resolution approaching 300 dots/in. The Chromajet 4000 can also print seven colors of text in letter-quality or draft mode in bold, italic, double-width, and condensed-type styles. The letter-quality mode has a 360×144-dot/in. resolution. The printer is self-priming and self-feeding for unattended operation. Each of the unit's four ink jets is capable of delivering 8000 drops/sec. A single, no-drip ink cartridge contains all four colors. From $2000 (OEM).

Polaroid Corp, 575 Technology Sq, Cambridge, MA 02139. Phone (617) 577-3796.

Circle No 359



TEXT SCANNER

- *300- or 200-dot/in. resolution*
- *Includes automatic sheet feeder*

The JetReader converts paper-based data into formatted disk files at rates that are typically less than a minute per page, depending on the quality of the original document. You can select a scanning resolution of 300 or 200 dots/in. The unit comes with optical character recognition (OCR) software that recognises 12 standard office type styles. You can order a JetReader Plus that includes software for programming the scanner to recognize additional type styles. Each unit incorporates an automatic sheet-feeder mechanism for unattended operation. From $2950; JetReader Plus, $3250.

Datacopy Corp, 1215 Terra Bella Ave, Mountain View, CA 94043. Phone (415) 965-7900.

Circle No 360

FILE SERVER

- *IBM PC/AT compatible*
- *Employs an 8-MHz 80286 μP*

The Starserver 10 is an IBM PC/AT-compatible file server for networks using the DOS operating system. Its CPU is an 8-MHz 80286 μP. A basic Starserver system comes with 60M bytes of disk storage, an RS-232C port, a Centronics port, a keyboard and monitor, MS-DOS operating system, and file-server software. You can expand this system to support as many as 16 simultaneous users and a maximum of 1.5M bytes of disk storage per user. You can install the processor yourself, because the Starserver 10 doesn't require any application or operating system reprogramming. From $11,495.

Datapoint Corp, 9725 Datapoint Dr, San Antonio, TX 78284. Phone (512) 699-5244.

Circle No 361

How to build Rome in a day.

Use the best project management software for empires of all sizes.

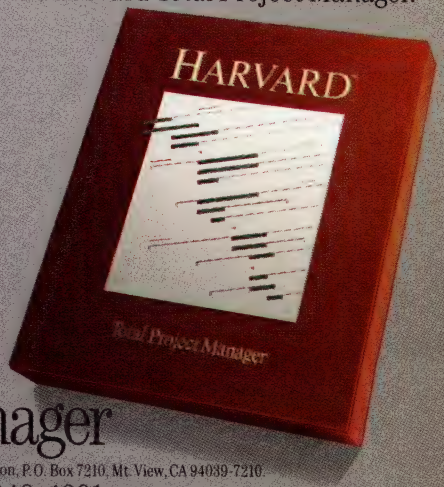
Whether you're launching a new product, constructing an office complex or planning to make history, Harvard™ Total Project Manager (HTPM) is the complete PC software program for anyone who wants to manage more effectively.

Successful project management starts with HTPM's intuitive roadmap (PERT Chart) which graphically demonstrates relationships between tasks and offers a clear view of the critical path. HTPM's Gantt Charts allow you to modify the project for the most efficient scheduling and resource allocation. You can also budget each task and compare actual costs to planned costs. If necessary, cost data can be transferred easily to Lotus™ spreadsheets. The flexible Project Calendar gives you the ability to define your workdays and tailor a project to fit your schedule.

Because most managers must juggle more than one project at a time, HTPM supplies a special feature that alerts you to over-committed resources, both within a project and across multiple projects, and helps you reallocate resources accordingly.

When a project requires the coordination of many people, good communication is vital. With HTPM you can produce comprehensive, presentation quality reports to keep the entire organization informed of the latest developments.

Any project can take on epic proportions when *you* are responsible for bringing it in on time and on budget. That's why every project manager needs HTPM. For planning, scheduling, controlling, and reporting, no PC software is as effective as Harvard Total Project Manager.



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CIRCLE NO 154

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CARLINGSWITCH
INNOVATION BY DESIGN

CIRCLE NO 113

ENCRYPTION MODEM

- *300-, 1200-, or 2400-bps rates*
- *EEPROM-based key lock*

Featuring a triple-encryption scheme, the Mesa modem offers such standard characteristics as error control, security, and automatic connection. You can select 300-, 1200-, or 2400-bps operation with Class 10 encryption and error control. Secure operation is ensured with a key lock. Each key contains an embedded EEPROM with 350 hexadecimal digits to identify and authenticate the user, dial the target phone number, and specify the encryption code. $995.

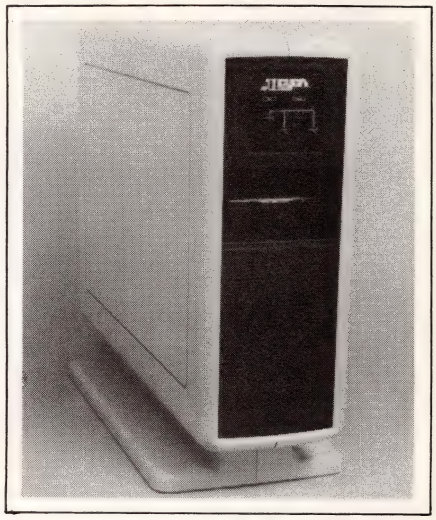
Western DataCom, 5083 Market St, Youngstown, OH 44512. Phone (216) 788-6583. TLX 910-333-8609.

Circle No 362

UNIX SYSTEMS

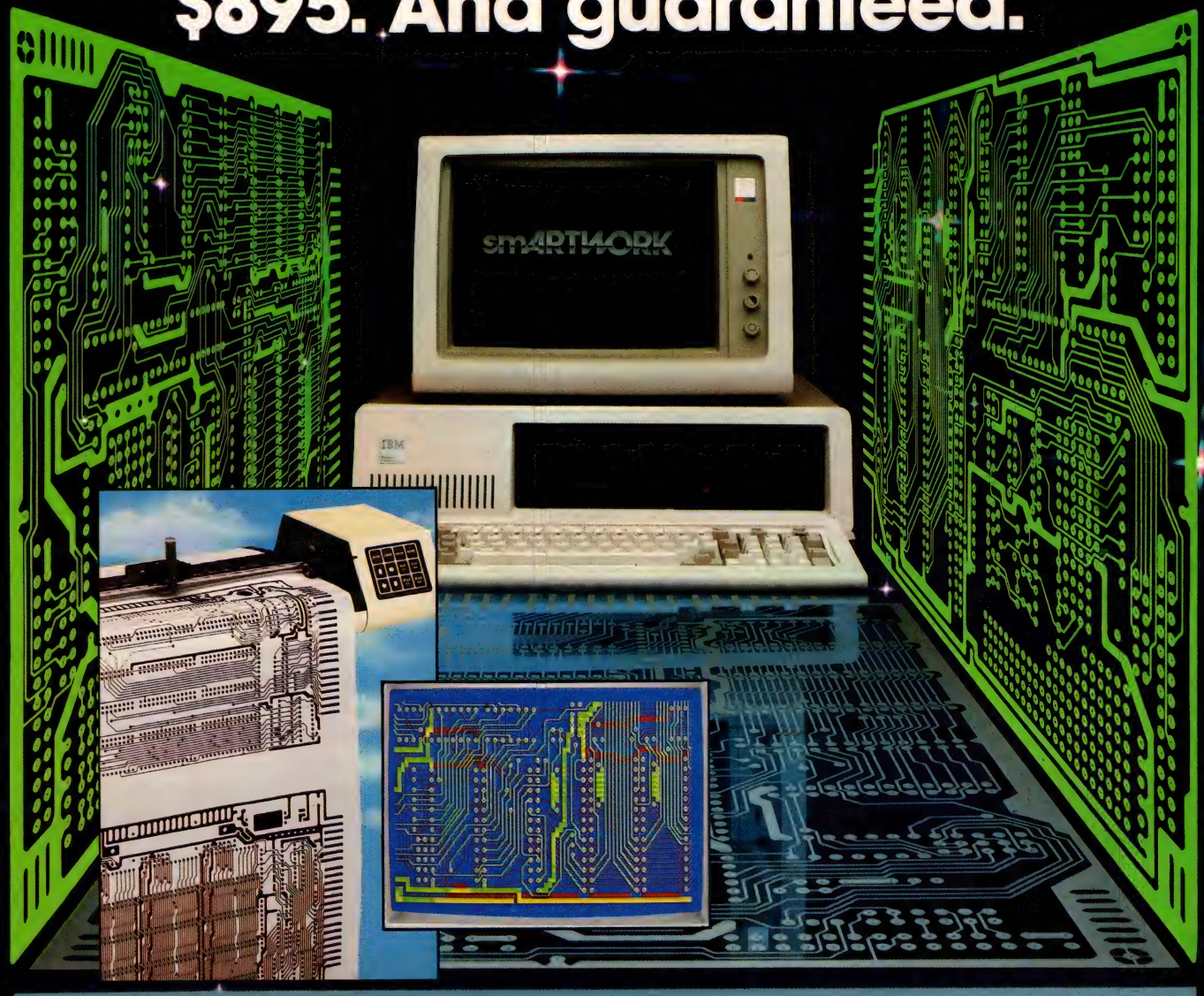
- *Based on VME Bus Unix 5.2*
- *Multiuser and multitasking*

Based on VME Bus Unix 5.2 systems, 10 real-time multitasking and multiuser systems include the Model 20, which gives one or two users 20M bytes of hard-disk capacity and a 5¼-in. floppy disk drive. Another one of the systems, Model 10/10, has a 10M-byte hard-disk drive with a 10M-byte removable Winchester backup drive. You can hook up from four to six terminals, each with 80M bytes of Winchester disk capacity and a 60M-byte tape cartridge, to the Model 80. Model



300 has a 300M-byte Winchester drive and a 60M-byte tape backup to accommodate eight to 12 users. Model 450 gives 12 to 16 users access to 450M bytes of disk capacity and a 9-track tape backup system. Each model is optionally available with two main processors and in a variety of enclosures. Each comes with Regulus, a real-time operating

Circuit-Board-Artwork Software: $895. And guaranteed.



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- ☐ Prototype-quality 2X artwork from a dot-matrix printer
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- ☐ Single-sided and double-sided printed circuit boards up to 10 x 16 inches
- ☐ Multicolor or black-and-white display

System Requirements:

- ☐ IBM Personal Computer, XT, or AT with 320K RAM, 2 disk drives, and DOS Version 2.0 or later
- ☐ IBM Color/Graphics Adapter with RGB color or black-and-white monitor
- ☐ IBM Graphics Printer or Epson FX/MX/RX series dot-matrix printer
- ☐ Houston Instrument DMP-41 pen-and-ink plotter
- ☐ Microsoft Mouse (optional)

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system. $7490 to $49,990.

Alcyon Corp, 5010 Shoreham Pl, San Diego, CA 92122. Phone (619) 587-1155. TLX 510-600-4047.

Circle No 363

50-MIPS COMPUTER

- *32-bit real-time system*
- *Employs a 68881 floating-point coprocessor*

Using parallel processing techniques, the Flex/32 is a 32-bit real-time multicomputer that can provide five to 50 MIPS in a machine that consists of one cabinet. You can achieve higher performance levels by linking several Flex/32 cabinets together in one system. This system is based on this company's C2C computer. Each C2C has a 16-MHz or 20-MHz 68020 μP and a 68881 floating-point unit. The C2C is compatible with the manufacturer's C1C units, which are based 32032 μPs. A typical configuration of the Flex/32 multicomputer with two C2C computers, 2M bytes of RAM, an 80M-byte hard-disk drive, a 67M-byte tape drive, and necessary software costs approximately $87,000 (OEM qty).

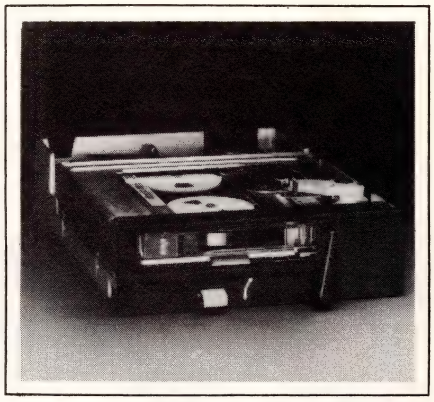
Flexible Computer Corp, 1801 Royal Lane, Bldg 8, Dallas, TX 75229. Phone (214) 869-1234.

Circle No 364

HALF-HEIGHT TAPE

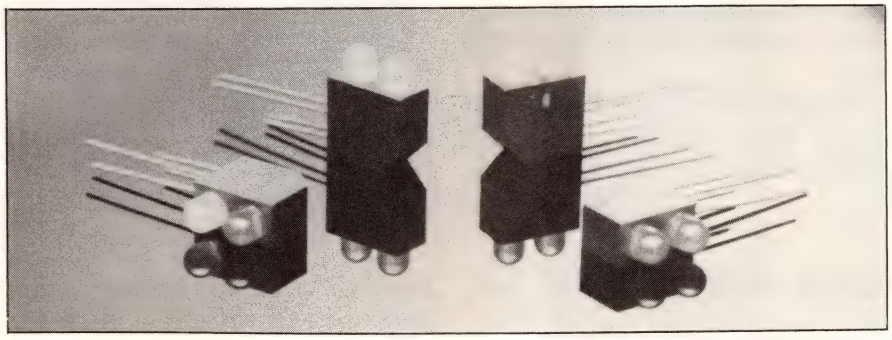
- *125M-byte storage capacity*
- *QIC-02 or SCSI interface*

The Roadrunner II is a cartridge tape drive that combines 125M bytes of storage capacity and a tape formatter containing a μP in a single half-height package. No separate formatter card is required. You can order the unit with either a QIC-02 or a SCSI interface. Proprietary VLSI custom ICs reduce the required electronics package, thus permitting all circuits to fit on two pc boards within the drive. Other features include a single-axis head-positioning mechanism and μP-controlled AGC (automatic gain control) on read. $775 to $995 (OEM qty).



North Atlantic Industries Inc, 60 Plant Ave, Hauppauge, NY 11788. Phone (516) 582-6060.

Circle No 365



DUAL LEDs

- *Allows piggyback configurations*
- *Packaged with T1¾ LEDs*

You can use the 21PCT200 line of high-intensity pc-board LEDs in piggyback configurations, which cuts assembly time substantially. The dual-LED package uses T1¾ high-efficiency LEDs. Each package is ¼ in. wide. Its mounting is designed to maintain alignment with the line center of the first (lower) LED at 0.125 in. from the pc board and the second (higher) LED mounted at 0.375 in. from the board. The four termination leads are spaced on 0.1-in. centers. To provide for flux and residue cleaning of the connections after assembly soldering, the black-nylon housing base of the LEDs has a relief area around the leads. You can order the packages with bright red (635 nm), yellow (585 nm), and green (565 nm) LEDs; the packages can have two colors. Brightness levels reach 3 cd. $0.75 (1000).

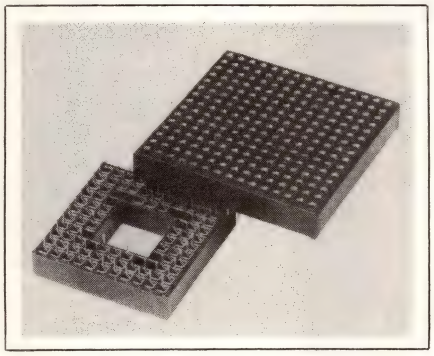
Ledtronics Inc, 4009 Pacific Coast Hwy, Torrance, CA 90505. Phone (213) 676-7996. TLX 4945454.

Circle No 366

PGA SOCKETS

- *0.25-in. max profile*
- *Accept 0.1-in. centerline ceramic chip carriers*

The Series 9085 pin-grid-array (PGA) sockets accept the standard and custom 0.1-in. centerline PGA ceramic chip carriers. Available in matrices from 10×10 to 15×15 with unlimited loading combinations, the sockets have a profile of 0.25 in. max. They accommodate cavity-up and cavity-down arrays with a variety of pin-polarizing options; optional cavity removal permits grid-array cover relief. The thermoplastic insulator sockets include beryllium copper contacts that are selectively plated with gold in the contact area and with solder on the through-board tails. Specifications include a 1.3-oz insertion force, 50g minimum



normal force, 25-mΩ maximum contact resistance, and 5000-MΩ insulation resistance. The dielectric withstanding voltage is 5000V dc, and the operating temperature is −55 to +85°C. $0.055/position (5000), fully loaded. Delivery, eight to 12 weeks ARO.

Elco Corp, Huntingdon Industrial Park, Huntingdon, PA 16652. Phone (814) 643-0700.

Circle No 367

VF DISPLAY

- *Features μP controller*
- *Has 0.2-in.-high characters*

The Model 3601-82-020 vacuum-fluorescent display features a 5×7-dot matrix and a 1×20-character display. It measures 6.92×2.2×0.68 in.; the characters are 0.2-in. high. An onboard μP controller handles all scan, refresh, and data I/O tasks, permitting interface to an 8-bit ASCII parallel data bus. The unit requires a 5V dc power supply. Display characters are blue-green. A spectrum of color filters is available. $64 (100). Delivery, four to six weeks ARO.

Industrial Electronic Engineers Inc, 7740 Lemona Ave, Van Nuys, CA 91405. Phone (818) 787-0311. TWX 910-495-1707.

Circle No 368

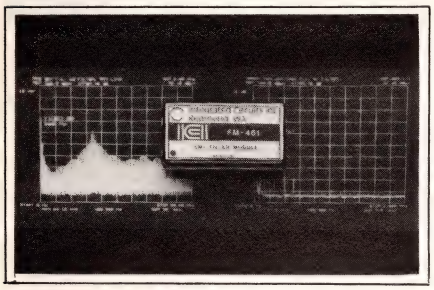
IBM PC CHASSIS

- *Comes with 150W supply*
- *Room for half-height peripherals*

This all-steel finished chassis includes a 150W, 4-output switching power supply, an 88-cfm cooling fan, and space for two half-height peripherals (hard disks, tape systems, or floppy disks). The IBM PC bus-compatible backplane has 1.0-in. spacing and is compatible with all expansion boards for the PC. The chassis is available in rack-mount, tabletop, or wall-mount styles; mounting holes are furnished for standard rack slides. Front panels are flat and can be removed for customizing. The unit measures 17×5.5×18.25 in. (the rack-mount panel is 7 in. high). Output voltage is 5V at 20A, −5V at 0.7A, 12V at 5A, and −12V at 1A. $749 (100).

I-Bus Systems, 9235 Chesapeake Dr, San Diego, CA 92123. Phone (800) 382-4229; in CA, (619) 569-0646.

Circle No 369



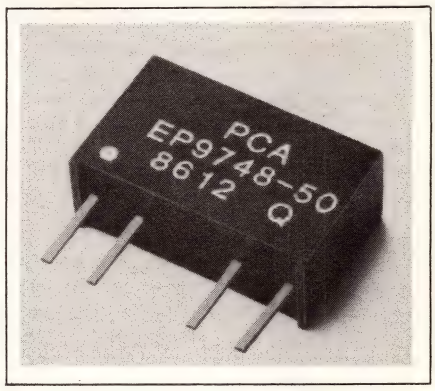
FILTER MODULE

- *Has common-mode and differential filtering*
- *Complies with MIL-STD-461, -704*

The FM 461 EMI/RFI filter module complies with MIL-STD-461 and MIL-STD-704 when used with this company's MLP, MHE, and MTO series of dc/dc converters. The module features both differential and common-mode filtering. The data sheet includes I/O transfer functions for use with other types of converters that have input currents to 1.75A dc. The 461 comes in a metal solder-sealed package that measures 1×2×0.375 in.; environmental screening per MIL-STD-883 is optional. $87 (100).

Integrated Circuits Inc, 10301 Willows Rd, Redmond, WA 98052. Phone (206) 882-3100. TWX 910-443-2302.

Circle No 370



DELAY LINES

- *Furnish one TTL-compatible output*
- *Measure 0.47×0.29×0.185 in. max*

The EP9748 Series active delay lines offer delays from 25 to 250 nsec ±5% or 2 nsec. Each delay line in the series provides a single TTL-compatible output. Maximum size of the epoxy case SIPs is 0.47×0.29×0.185 in. They have four leads, arranged on a 100-mil grid, including V_{CC}, ground, input, and output. One 5V supply is needed; typical current is 20 mA. Operating range is 0 to 70°C. The devices have buffered inputs and outputs; standard output buffers drive 10 Schottky loads with a maximum rise time of 4 nsec. Other versions are available with low-power Schottky buffers. $2 (1000). Delivery, stock to six weeks ARO.

PCA Electronics Inc, 16799 Schoenborn St, Sepulveda, CA 91343. Phone (818) 892-0761.

Circle No 371

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MicroWay is the world's leading retailer of 8087s and high performance PC upgrades. We stock a complete selection of 8087s that run from 5 to 12 MHz. All of our coprocessors are shipped with a diagnostic disk and the best warranty in the business – one year! We also offer daughterboards for socketless computers (NEC PC) and 287Turbo which increases the clock speed of the 80287 from 4 to 10 MHz. Our NUMBER SMASHER/ECM™ runs at 12 MHz with a megabyte of RAM and achieves a throughput of .1 megaflops with 87BASIC/INLINE, Intel Fortran, or Microsoft Fortran. Software reviewers consistently cite MicroWay software and 8087 expertise as the best in the industry! Our customers frequently write to thank us for recommending the correct software and hardware to meet their specific needs. They also thank us for our same-day shipping! In addition to our own products which support the 8087 and 80287, we stock the largest supply of specialized software available. For more information call us at

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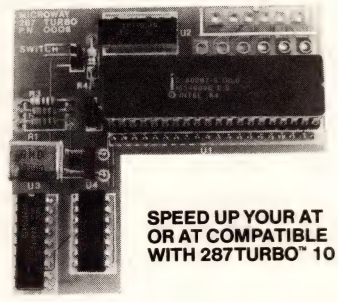

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RM, IBM, MS Fortran ..... **CALL**

MegaPage™ Our Intel-Lotus EMS memory card. The only EMS board which comes with two megabytes of cool-running, low power drain CMOS RAM installed. Includes RAM disk, print spooler, disk cache, and EMS drivers. For the IBM PC, XT and compatibles..... **$549**

MegaPage AT/ECC™ EMS card for the PC AT and compatibles includes Error Correction Circuitry. With ECC, 11 RAM chips cover 256K so the user never encounters RAM errors. With 1 megabyte CMOS **$799**; with 3 megabytes CMOS **$1295**. Optional serial/parallel daughterboard..... **$95.**

DFixer™ Our disk utility which thoroughly checks PC or AT hard disks for bad sectors and updates the MS DOS file allocation table accordingly. Solves the AT hard disk problem! ... **$149**

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DCache™ Our disk caching software speeds up your I/O by storing repetitively used tracks in memory. The amount of memory used can be selected in 64 Kbyte banks **$49**

87MACRO/DEBUG™ Contains all the pieces needed for writing 8087/80287 assembly code & MicroWay's 87DEBUG debugger **$199**

OBJ→ASM™ A multipass object module translator and disassembler. Produces assembly language listings which include public symbols, external symbols and labels commented with cross references. Ideal for patching object modules for which source is not available..... **$200**

87BASIC™ includes patches to the IBM BASIC or MS Quick BASIC Compiler for USER TRANSPARENT 8087 support. Provides super fast performance for all numeric operations including trigonometrics, transcendentals, addition, subtraction, multiplication, and division..... each **$150**

87BASIC/INLINE™ converts the output of the IBM BASIC Compiler into optimized 8087 inline code which executes up to seven times faster than 87BASIC. Supports separately compiled inline subroutines which are located in their own segments and can contain up to 64 Kbytes of code. This allows programs greater than 128K! Requires the IBM BASIC Compiler Version 1 and a Macro Assembler. Includes 87BASIC ... **$200**

In London, please phone 223-7762

8087 UPGRADES

All MicroWay 8087s include a one year warranty, complete MicroWay Test Program and accurate installation instructions.

8087 5 MHz..... **$109**
For the IBM PC, XT and compatibles.

8087-2 8 MHz..... **$149**
For Wang, AT&T, DeskPro, NEC, Leading Edge.

80287-3 5 MHz..... **$179**
For the IBM PC AT and 286 compatibles.

80287-6 6 MHz..... **$229**
For 8 MHz AT compatibles.

80287-8 8 MHz..... **$295**
For the 8 MHz 80286 accelerator cards.

NEC V20, V30..... **$16, $30**
64K RAM Set 150ns..... **$10**
256K RAM Set 150ns..... **$34**
256K RAM Set 120ns..... **$39**
128K RAM Set PC AT..... **$49**

287Turbo™ 10 MHz If you own an AT, Deskpro 286 or AT compatible, this is the card you need to get reasonable numeric performance. It plugs into your 80287 socket and includes a specially driven 10 MHz 80287. The card comes in three configurations. The IBM AT version includes a hardware RESET button **$450**

287Turbo 8 MHz..... **$369**

87/88Turbo™ is a stubby card which includes a clock calendar and a speed controller which changes the speed of your motherboard from 4.77 to 7.4 MHz. Its use requires your PC to have a socketed 8284. Typical speed increase is 1.6 to 2.0. The card overcomes slow hardware by slowing up only when such devices are accessed and running at full speed otherwise **$149**
Optional 8087-2 ..... **$149**

286TurboCache™ This new MicroWay accelerator uses 8K of cache memory and 80286/80287 processors to provide an average speed increase of 3:1 for most programs. Call for specifications and benchmarks **$595**

Call for our complete catalog of software which supports the 8087.

MicroWay
P.O. Box 79
Kingston, Mass.
02364 USA
(617) 746-7341

ATTENUATORS

- *Handle 3W*
- *Insertion loss ranges from 0.1 to 0.7 dB*

The 431HW and 432HW attenuators can handle an average of 3W. The 432HW has an attentuation range of dc to 1000 MHz (50Ω) with a minimum step of 1 dB. VSWR is 1.2:1 over the frequency range of dc to 250 MHz, 1.3:1 over the 250- to 500-MHz range, and 1.4:1 over the frequency range of 500 to 1000 MHz. Insertion loss is 0.1 dB (dc to 250 MHz), 0.3 dB (250 to 500 MHz), and 0.7 dB (500 to 1000 MHz). The 432HW can handle 3W typ at 12.25V rms continuous operation at 25°C. You must derate 10% for each 10°C rise above 25°C. The 431HW has an attenuation range of dc to 41 MHz (50Ω). Both models are available with BNC connectors. 431HW, $304; 432HW, $350.

Kay Elemetrics Corp, 12 Maple Ave, Pine Brook, NJ 07058. Phone (201) 227-2000. TWX 710-734-4347.

Circle No 372

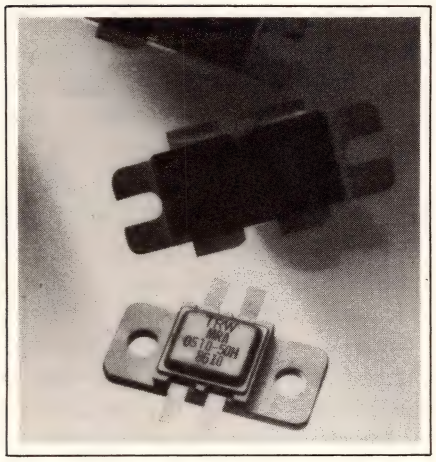
DPMs

- *Includes 3½-digit LED*
- *Features ±0.05% accuracy and linearity*

You can order the Model 516 digital panel meters with a 3½-digit LED in 11 different ranges: 50 mV, 200 mV, 2V, 20V, 200V, 500V, 200 μA, 2 mA, 20 mA, 200 mA, and 2V ratiometric. They feature programmable decimal points and single-ended and differential inputs. Accuracy and linearity are ±0.05% full scale. Maximum power input is 5V dc; input impedance is 1000 mΩ. The meter has 100% overrange protection and operates at 4 samples/sec. Three mounting styles are available: The Flat Pack measures 2×3×0.5 in. and is mounted on the front of the panel through a ⅜-in. hole. This unit is supplied with a plastic housing. The Naked Panel Mount is 1.9×3.5×0.5 in. and is mounted behind the panel by using stand-offs. This unit has a ribbon connector. The Naked PC Mount measures 1.9×2.9×0.5 in. and is mounted behind the panel on a pc board or a connector; it can also be terminated with wire wrap. $52. Delivery, stock to six weeks ARO.

International Microtronics Corp, 4016 E Tennessee St, Tucson, AZ 85714. Phone (602) 748-7900. TWX 910-952-1170.

Circle No 373



RF TRANSISTORS

- *Ranges span 100 to 1000 MHz*
- *Family members provide 7 or 7.5 gain*

The MRA0510-50H, MRT0105-75, and MRT0105-75V devices are broadband, push-pull, high-power, class-AB bipolar amplifiers. Respectively, the devices provide 50, 75, and 75W of cw linear power. The MRA0510-50H comes in a solder-sealed hermetic package; it features a gain of 7 dB min at 1000 MHz and 28V. The device is usable over a 500- to 1000-MHz frequency range. It can withstand a 5:1 voltage standing-wave ratio (VSWR) at 1000 MHz with a power output of 50W. The MRT0105-75 has a gain of 7.5 dB min at 500 MHz and 28V. It's usable over a 100- to 500-MHz frequency range. The device can withstand a 5:1 VSWR at 100 MHz with a power output of 75W. The MRT0105-75V device has a gain of 7 dB min at 500 MHz and 18V; it's also usable over a 100- to 500-MHz frequency range. It can withstand a 10:1 VSWR at 100 MHz with a power output of 75W. MRA0510-50H, $146.50; MRT0105-75, $111; MRT0105-75V, $114.10 (100).

TRW Inc, RF Devices Div, 14520 Aviation Blvd, Lawndale, CA 90260. Phone (213) 536-0888.

Circle No 383

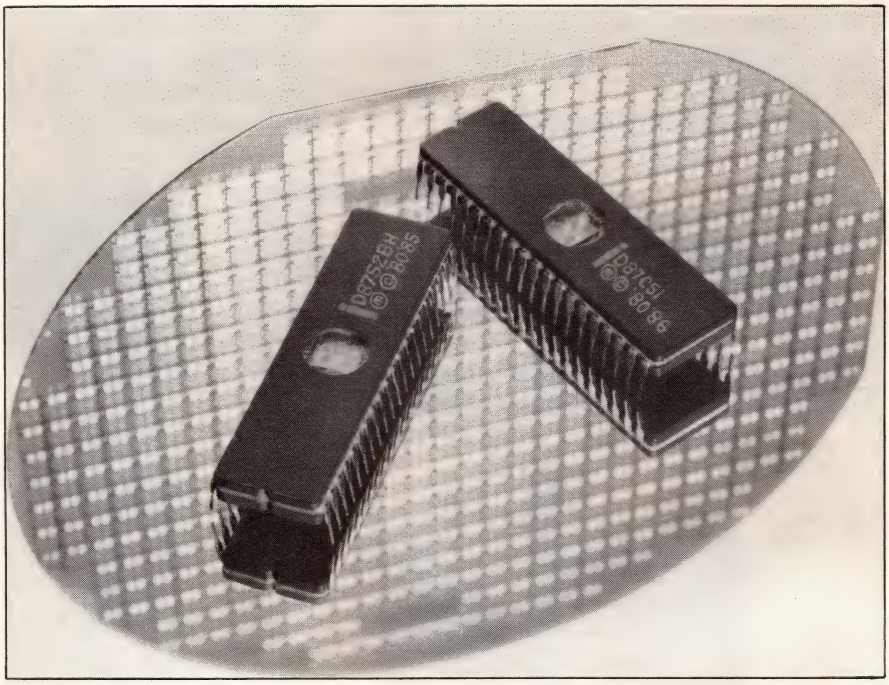
DYNAMIC RAM

- *NMOS RAM has 64k×4-bit organization*
- *Access times are 100, 120, and 150 nsec*

The MSM41464 is a 64k×4-bit NMOS dynamic RAM with access times of 100, 120, and 150 nsec. The device features column-address strobe ($\overline{CAS}$) before row-address strobe ($\overline{RAS}$). The refresh-control clock generator and the refresh address counter on the chip provide automatic refresh, which eliminates the need for an external circuit for refresh addressing. Hidden refresh makes it possible to refresh another address while holding the data output from the preceding read cycle by extending the $\overline{CAS}$ pulse width from that read cycle. The device also features page-mode function that saves power because it eliminates frequent $\overline{RAS}$ activity. In 18-pin DIPs: 120-nsec device, $6; 150-nsec device, $5.60 (100).

Oki Semiconductor, 650 N Mary Ave, Sunnyvale, CA 94086. Phone (800) 336-3555; in CA (408) 720-1900. TWX 910-338-0508.

Circle No 384



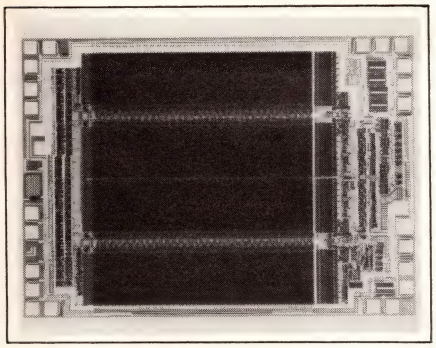
MICROCONTROLLERS

- *EPROM versions of the MCS-51 family*
- *Built-in Boolean processors manipulate bit-level data*

The 87C51 and 8752 are high-speed EPROM versions of the MCS-51 microcontroller family. The devices feature built-in Boolean processors for bit-level data manipulations, and they offer 32 programmable I/O ports. The 87C51 has 4k bytes of EPROM program memory; the 8752 microcontroller contains 8k bytes of EPROM with three 16-bit timer/counters that allow the device to count events. Both chips offer a 2-level program-memory lock feature for protection against software piracy. In 40-pin DIPs: 87C51, $52; 8752, $55 (1000).

Intel Corp, Literature Dept W299, Box 59065, Santa Clara, CA 95052. Phone (602) 961-8420.

Circle No 385



STATIC RAMs

- *4k×4-bit parts spec 25-nsec access time*
- *Write and read pulses can overlap*

The CY7C171 and CY7C172 4k×4-bit static RAMs come in versions that feature a 25-nsec access time and separate I/O, which allows you to place write data on the write lines while the read data is being accessed. The devices are used for such applications as writable control stores, cache memory, and display planes. In the 7C172, the transparent-write feature allows the written word to appear at the output pins in an interval that does not exceed the device's access time. The RAMs operate over a 0 to 70°C temperature range and come in 24-pin, 300-mil plastic and ceramic DIPs. CY7C171-25PC and CY7C172-25PC (25 nsec), $23.20 (100).

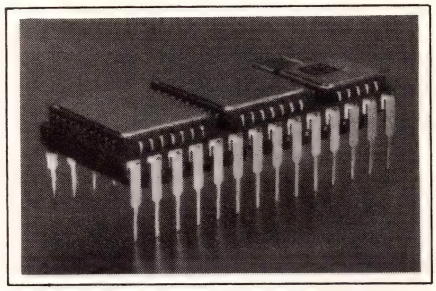
Cypress Semiconductor Corp, 3901 N First St, San Jose, CA 95134. Phone (408) 943-2666.

Circle No 386

STATIC RAM

- *CMOS module comprises four 8k×8-bit memories*
- *Pin compatible with JEDEC 28-pin, ×8 devices*

The EDH8832CL memory module comprises four 8k×8-bit CMOS static RAMs, plus a decoupling capacitor and decoder, mounted on both sides of a ceramic substrate in a 600-mil DIP. The substrate provides pin compatibility between the device and JEDEC's 28-pin, ×8 memory pinout. The device is static, requires no clocks, and has $\overline{E}$ chip-enable and $\overline{G}$ output-enable functions for bus control. The module is available in 150- and 200-nsec access versions. 150-nsec version, $277; 200-nsec version, $230 (1000). Delivery, 12 weeks ARO.



Electronic Designs Inc, 35 South St, Hopkinton, MA 01748. Phone (617) 435-9077. TLX 948004.

Circle No 387

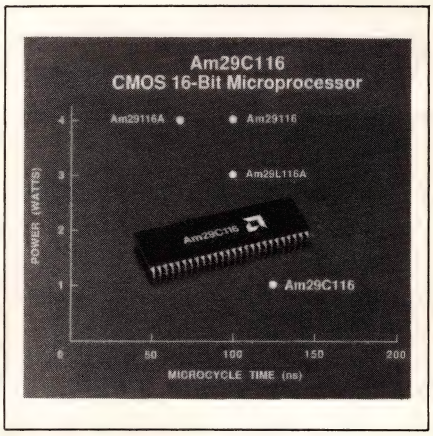
MICROCOMPUTER

- *On-chip EEPROM stores calibration information*
- *Includes 256-byte RAM and 8-bit pulse accumulator*

The MC68HC811A2 μC features an EEPROM that allows you to store field and factory calibrations on the chip. The device contains 256 bytes of RAM, an enhanced 16-bit timer system with three input captures and five output-compare functions, and an 8-bit pulse accumulator. Also included is an asynchronous serial communications interface; a synchronous serial peripheral interface; an 8-channel, 6-bit A/D converter, parallel handshake ports; a bootstrap-loader ROM; and real-time interrupt circuitry. The device also features software-programmable power-saving modes (wait and stop). It runs at a 2.1-MHz bus speed over the −40 to +125°C temperature range. $125.

Motorola Inc, Microprocessor Products Group, Box 52073, Phoenix, AZ 85072.

Circle No 388



MICROPROCESSOR

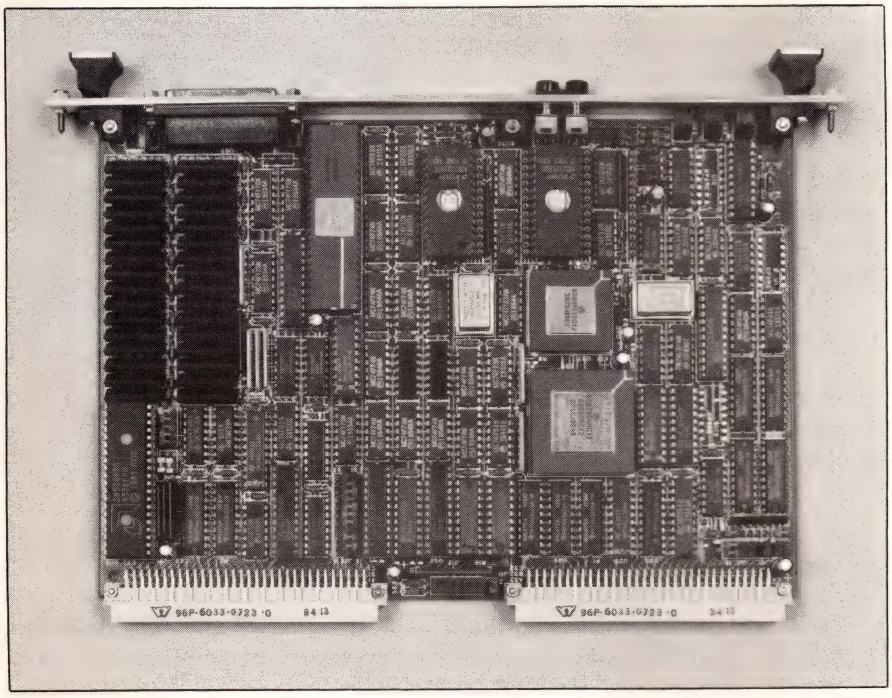
- *Pin and function compatible with Am29116*
- *CMOS μP consumes 1W less than bipolar counterpart*

The Am29C116 is pin and function compatible with the manufacturer's industry-standard Am29116. The device reduces power consumption by 1W, a savings of more than 75% over the Am29116 bipolar device. Like the AM29116, the device integrates a barrel shifter, 32 working registers, a 3-input ALU, and a priority encoder. The 3-input ALU operates on two data operands, and the third input allows 2-operand instructions with masking. The 16-bit barrel shifter can shift or rotate a word in as many as 15 positions in a single instruction cycle. The device accommodates a 125-nsec system cycle time, or an 8-MHz data rate. In a 52-pin ceramic DIP, $49 (100).

Advanced Micro Devices Inc, Box 3453, Sunnyvale, CA 94088. Phone (408) 732-2400.

Circle No 389

COMPUTER-SYSTEM SUBASSEMBLIES



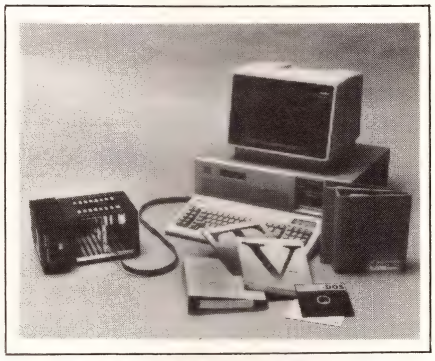
32-BIT COMPUTER

- *Offers 12.5- or 16.67-MHz clock frequency*
- *Four 28-pin JEDEC sockets available for memory*

The MVME133, a 32-bit VME Bus-compatible μC board, incorporates the MC68020 μP, the MC68881 floating-point math coprocessor, and 1M byte of dynamic RAM. This single-board computer comes in two versions: the MVME133 with a 12.5-MHz clock frequency, and the MVME133-1 with a 16.67-MHz clock frequency. Both have four 28-pin JEDEC sockets for ROM, PROM, EPROM, and EEPROM. Other features include serial debugging and two RS-232C multiprotocol I/O ports, three 8-bit timers, a real-time clock, and an A24/D32 VME Bus master interface that can serve as a system controller. An optional firmware package, the MVME-133bug debug monitor, offers 32 debugging, up/downline-loading, and disk-bootstrap-load commands; onboard diagnostics; and a 1-line assembler / disassembler with MC68881 support. MVME133 with 12.5-MHz MC68020, $1700 (OEM qty).

Motorola Semiconductor Products Inc, Box 20912, Phoenix, AZ 85036. Phone (602) 438-3501.

Circle No 390



DOS-BASED SYSTEM

- *OS achieves 100-μsec interrupt response time*
- *RAM board provides 256k bytes*

Combining PC-DOS and VRTX (virtual real-time executive), the STD Multi-DOS system allows you to create a multitasking computer. The development system contains a ZT 8806 or ZT 8807, the ZT 8824 MegaRAM board (256k bytes), a card cage with a power supply, cables, and documentation. The 8088-based operating system has a 100-μsec interrupt response time and can access PC-DOS-compatible device drivers and generate IBM PC-compatible files. Multiple real-time tasks operate independently via VRTX; while VRTX tasks execute in real time, the PC-DOS utilities pose no additional overhead. Development system hardware and software, including licenses for software, $6000; target system, including fees for Multi-DOS and VRTX, $1145.

Ziatech Corp, 3433 Roberto Ct, San Luis Obispo, CA 93401. Phone (805) 541-0488. TLX 4992316.

Circle No 391

SERIAL CONTROLLER

- *32- or 24-bit addressing is possible*
- *Programmable baud rates span 50 to 19.2k*

The V/SIO 3208, a serial-communications controller, has eight independent, full-duplex RS-232C channels on one VME Bus board. It provides four software-programmable interrupts for each of its eight channels (32 interrupts total); each receive channel has a FIFO buffer. The controller offers programmable baud rates from 50 to 19.2k; asynchronous, synchronous, and SDLC (synchronous data-link control) bit-synchronous modes; modem control; and local loop-back and auto-echo modes. It also features 32- or 24-bit addressing, and it provides RS-232C signals on both individual headers on the front of the board and on the P2 standard DIN connector on the back. $795.

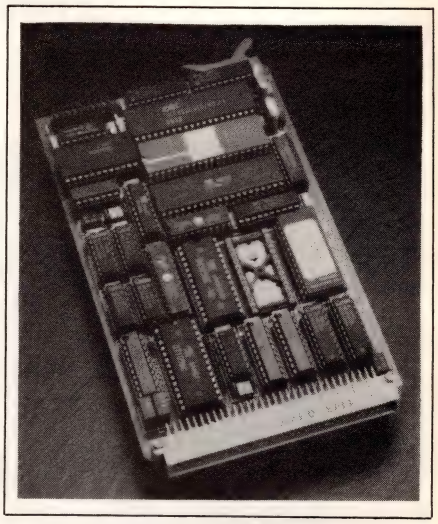
Interphase Corp, 2925 Merrell Rd, Dallas, TX 75229. Phone (214) 350-9000. TLX 732561.

Circle No 392

COMPUTER-SYSTEM SUBASSEMBLIES

MULTIBUS II CARDS

- *256k-byte dynamic-RAM capacity, expandable to 512k bytes*
- *Connects to Ethernet LANs*



Two communications boards, the iSBC 186-530 and the iSBC 186/410, provide respective networking and I/O capabilities for Multibus II systems. Both cards contain 256k bytes of dynamic RAM (expandable to 512k bytes). The iSBC 186/530 board connects to Ethernet LANs. It offloads one or more host CPUs by executing network-communications tasks; its networking is independent of each CPU's host. The board uses an 82586 Ethernet controller and includes an RS-232C port. Its host-to-controller firmware lets you run communications software at the board level. The iSBC 186/410 provides six serial channels (expandable to 10); and four 28-pin JEDEC memory sites. It can act as either a communications server for multiuser, multiprocessing systems or as a terminal or cluster controller. This board can run such communications protocols as X.25, SNA, LU.2, and TCP/IP concurrently, and it can also simultaneously support host-communications functions and direct terminal I/O. iSBC 186/530, $2395; iSBC 186/410, $2595.

Intel Corp, 3065 Bowers Ave, Santa Clara, CA 95051.

Circle No 393

1-BOARD COMPUTER

- *Includes RS-232C interfaces*
- *Can furnish 32k bytes of onboard nonvolatile memory*

The CMX-850, an 80C88-compatible single-board computer, consumes 80 to 90 mA at 5V dc and 5 mA at ±15V dc for systems operating at 5 MHz. Programmable clock-slowing capabilities can cut power consumption even further. The computer uses NEC's 8088-compatible V20 processor and will accept either an NMOS or CMOS version of the 8087 math coprocessor. Three JEDEC standard 28-pin sockets accept 32k×8-bit ROMs. As an option, the manufacturer can configure one socket to accept RAM devices; this socket can also provide battery backup for as much as 32k bytes of onboard nonvolatile memory. Two independent serial channels incorporate low-power RS-232C interfaces; each channel is configurable for interrupt-driven operation. The system provides parallel I/O (eight digital outputs and seven digital inputs); these inputs include interrupt-driven change-of-state detectors. A 3-channel counter/timer generates off-board timebases and system clock signals; an 82C59A controller processes interrupts. The system is compatible with the company's proprietary bus, Cimbus, and operates over −40 to +85°C. $595.

Citadel Computer Corp, 2 Caldwell Dr, Amherst, NH 03031. Phone (603) 880-6200. TLX 0258194.

Circle No 394

COMBINATION PACKAGE

- *Includes all necessary hardware and software for interfacing*
- *Allows acquisition of analog, digital, and counter data*

The PCI Controlograph is an IBM PC-compatible hardware/software system for data logging, graphics display, alarm enable, and digital

COMPUTER-SYSTEM SUBASSEMBLIES

control. Using menus, you can acquire analog, digital, or counter data; translate the data into engineering units; set limits for, and enable, alarms; and actuate digital outputs for control purposes. You also can display the data as it is being stored on disk. Inputs can comprise 21 analog signals, 24 digital bits, and 3 frequency/event counting channels. You can select one of four input-voltage ranges or J-, K-, or T-thermocouple ranges. System hardware consists of a carrier board, three instrumentation modules, two termination panels, and two cables. Complete system, $2720; software only, $795.

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 395

EXPANSION MEMORIES

- *Compatible with the IBM RT PC*
- *40-bit arrays permit interleaved operation*

Two boards, the RTRAM/4 and the RTRAM/8, allow you to configure as much as 16M bytes of memory in an IBM RT PC. The RTRAM/4 has a 4M-byte capacity using 256k-bit dynamic RAMs (encased in ZIPs, or zigzag in-line packages); the RTRAM/8 has an 8M-byte capacity using 1M-bit dynamic RAMs (encased in DIPs). Both boards are IBM compatible and support the RT PC error-detection and -correction logic. Each is organized as two 40-bit arrays to allow interleaved operation; access time is 150 nsec. The RTRAM/4 draws 1.9A; the RTRAM/8 draws only 1.4A because of the fewer number of dynamic RAMs. RTRAM/4, $1895; RTRAM/8, $4395.

Clearpoint Inc, 99 South St, Hopkinton, MA 01748. Phone (617) 435-5395. TLX 298281.

Circle No 396

NEW PRODUCTS

INSTRUMENTATION & POWER SOURCES

6870X EMULATOR

- *Supports four breakpoints*
- *Needs no intermediate EPROM*

The PEM-05 is an emulator/programmer for the 68705 single-chip μP family. The device programs the 68703P3, 68705R3, or the 68705U3 without an intermediate EPROM. In the emulation mode, the emulator can display memory, registers, and port status during program execution. You can step through code as well as set or clear any of four breakpoints, the emulation memory, or any register or port. You can both execute programs and program the target μP via commands from any serial terminal. The results are displayed on front-panel LEDs and also displayed as status messages sent to the terminal. $695.

Mojave Cyber Research, Box 2502, Apple Valley, CA 92307. Phone (619) 247-9691.

Circle No 397

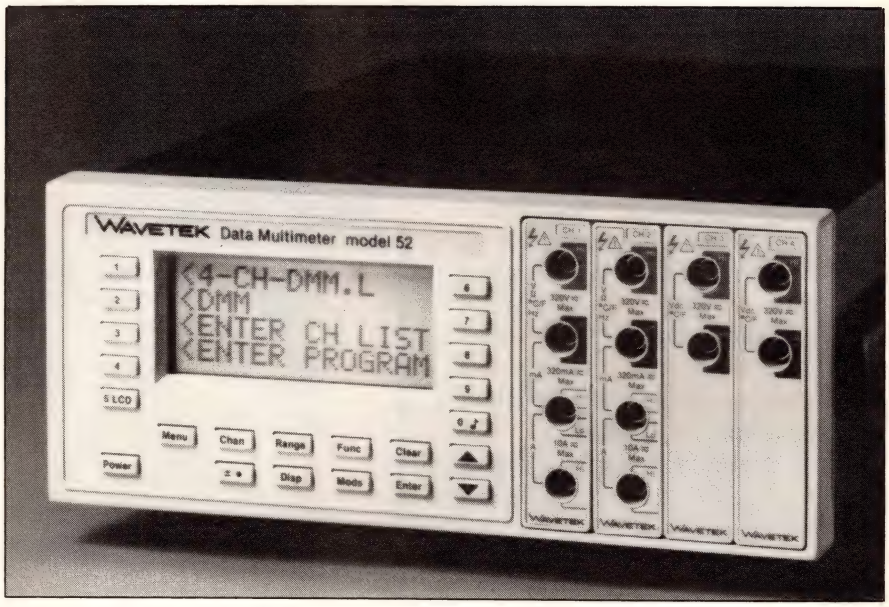
SYNTHESIZERS

- *100-MHz clock rates*
- *12-bit vertical resolution*

The 2020-100 (remote only) and 2000-100 waveform synthesizers have clock rates as fast as 100 MHz with 12-bit vertical resolution. You can expand the waveform memory to 512k data points. The longest duration transient that the synthesizer can generate when running at the 100-MHz clock rate is over 5 msec. You can obtain even longer waveform outputs by the memory-conservation techniques of dynamic looping and dc compression. 2020-100, $11,995; 2000-100, $12,995. Delivery, 60 days ARO.

Data Precision, Div of Analogic Inc, 16 Electronics Ave, Danvers, MA 01923. Phone (617) 246-1600. TLX 6817144.

Circle No 398



LOGGING DMM

- *Stores 97,000 data points*
- *Six-digit resolution*

Models 51 and 52 multimeters each combine the functions of a digital multimeter, a data-logger/data-acquisition system, and a process controller. Both feature 6-digit resolution, 1-mV sensitivity, accuracy to 0.04%, and data rates to 40 readings/sec. Data-logging capacity is approximately 97,000 data points. They can operate from an internal lead-acid battery for 100 hours. Model 52 handles as many as four plug-in modules and can make four independent sets of measurements simultaneously. In an optional multiplex mode, each plug-in can handle as many as 60 sensors. Model 52 includes a bit-mapped LCD and standard RS-232C and optional IEEE-488 interfaces for remote control and data transfer (Model 51 is remote only). The devices also include measurement functions such as temperature, dB, frequency, period, time interval, pulse width, and continuity. They can calculate functions such as delta, delta percent, min/max average, and alarm limits. Each unit measures 3.5×8.5×12.1 in. Both models cost less than $3000.

Wavetek Corp, 9191 Towne Centre Dr, Suite 450, San Diego, CA 92122. Phone (619) 450-9971.

Circle No 399

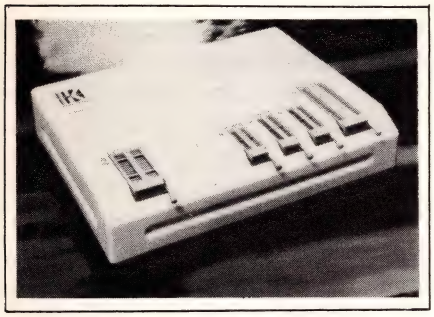
TELECOMM SUPPLY

- *Furnishes 48V at 200W*
- *Uses saturable-reactor regulation*

Model 1124 is a 48V dc input, 200W, multiple-output power supply. The device uses saturable-reactor regulation in the main as well as the auxiliary outputs. This regulation allows a packaging density of 1.28W/in^3. The supply operates in temperatures to 50°C with no derating. The device delivers 5V at 20A, 12V at 3A, −12V at 2A, −5V at 0.5A, and 24V at 2A with a 3A surge rating. The 24V output was specifically designed for disk-drive applications. All outputs are current limited and have continuous overload and short-circuit protection. In a 2.7×5.25×11-in. package, $395.

RO Associates Inc, Box 61419, Sunnyvale, CA 94088. Phone (408) 744-1450. TWX 910-339-9304.

Circle No 400



PLD PROGRAMMER

- *Handles 20- and 40-pin devices*
- *Performs PROM checksum tests*

The UPM/C programming module handles EPROMs and 20- or 40-pin PAL devices. The device can accommodate its manufacturer's PA-48 adapter (for programming Advanced Micro Devices' 27C1024) as well as the company's EPP-80 and MPP-80 programming stations. The module can program megabit EPROMs and Monolithic Memories' Mega PALs. The device is also capable of additional tests such as the continuous monitoring of the power supply to −15%; power-on test with hardware and software check; detection of shorts on data lines; and checksum of PROM contents. The device can also produce an EPROM master from PAL devices, thus effecting a low-cost solution for storing PAL data for duplication. $3900. Delivery, four to six weeks ARO.

Kontron Electronics, 1230 Charleston Rd, Mountain View, CA 94039. Phone (415) 965-7020.

Circle No 401

ANALYZER PROBE

- *100-psec resolution*
- *Works with K450 logic analyzer*

The HR1000/ATC is an accessory for its manufacturer's K450 logic analyzer; the probe measures repetitive signals with a 100-psec resolution across eight channels. To ensure accuracy, the device uses autocalibration at the probe tip. The time measurement is displayed as a digital number, which is updated in real time as the cursors are scrolled to different measurement positions on the signal waveforms. This scrolling eliminates guessing at the exact time between two points on any of the eight signal waveforms. A pop-up menu lets the user specify the time resolution and the channels to be measured. $4994. Delivery, 60 days ARO.

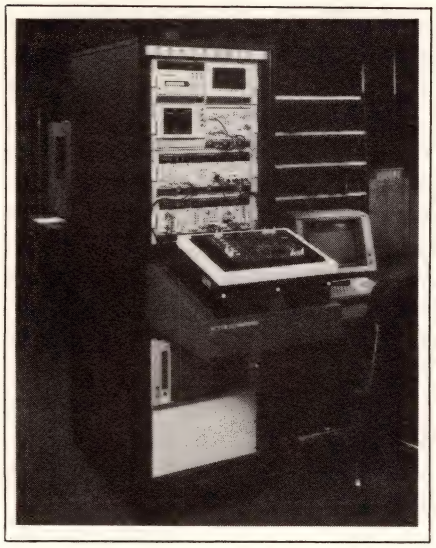
Gould Inc, Design & Test Systems Div, 19050 Pruneridge Ave, Cupertino, CA 95014. Phone (408) 988-6800. TWX 910-338-0509.

Circle No 402

TEST INTERFACE

- *Handles dc to 18 GHz*
- *IEEE-488 controlled*

The TSI-8150 is a test-system interface that includes a family of signal-switching units to handle signals



from low-level dc to 18 GHz. The two primary components of the system are the main chassis and the device-under-test (DUT) adapter. Reconfigurable and IEEE-488 controlled, the system provides real-time, stored-sequence signal switching; remote signal switching; and an expansion chassis that holds nine additional switching cards or modules. You can mount the full family of switching cards and modules in the main chassis, in the optional expansion chassis, or in optional auxiliary mounting units. The unit has an IEEE-488 (GPIB) port and two independent counter/timer channels. The system has 10 general-purpose and three special-purpose trigger lines. From $8000.

Tektronix Inc, Marketing Communications Dept, Box 1700, Beaverton, OR 97005. Phone (800) 547-1512; in OR, (800) 452-1877.

Circle No 403

68020 EMULATOR

- *Clock speeds to 12.5 MHz*
- *2046-word trace memory*

As a dedicated unit, the 68020 emulator is functionally and electrically transparent to the target system and permits clock speeds to 12.5 MHz. The device's trace memory captures 2046 words of 72-bit processor cycles. You can control the emulation by breaking on any combination of address, data, status, pass counter, and logic state fields. You can use either an event or combination of events (as defined by logic statements) to break emulation, trace software sequences, count events, or generate trigger outputs. The 32k-byte emulation memory is expandable to 512k bytes. A 16-channel logic-state probe is optional. You can upgrade the manufacturer's ES 1800 16-bit emulators for 68020 emulation by adding a board set and a pod. 68020 emulator, $11,295; upgrade of ES1800 to 68020, $6745. Delivery, 90 days ARO.

Applied Microsystems Corp, Box 97002, Redmond, WA 98073. Phone (800) 426-3925; in WA, (206) 882-2000.

Circle No 404

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The Versatec Spectrum electrostatic plotter/printer does it all. Plots A (11" x 8½") and B (11" x 17") page drawings. Plots in full color or black and white. Prints software listings, parts lists, reports, or other alphanumeric printing with a built-in character generator at 1000 lines per minute. Produces hard copies direct from monochrome or color displays with an optional video interface that includes a frame-buffer. And all at a lower cost per copy than other technologies.

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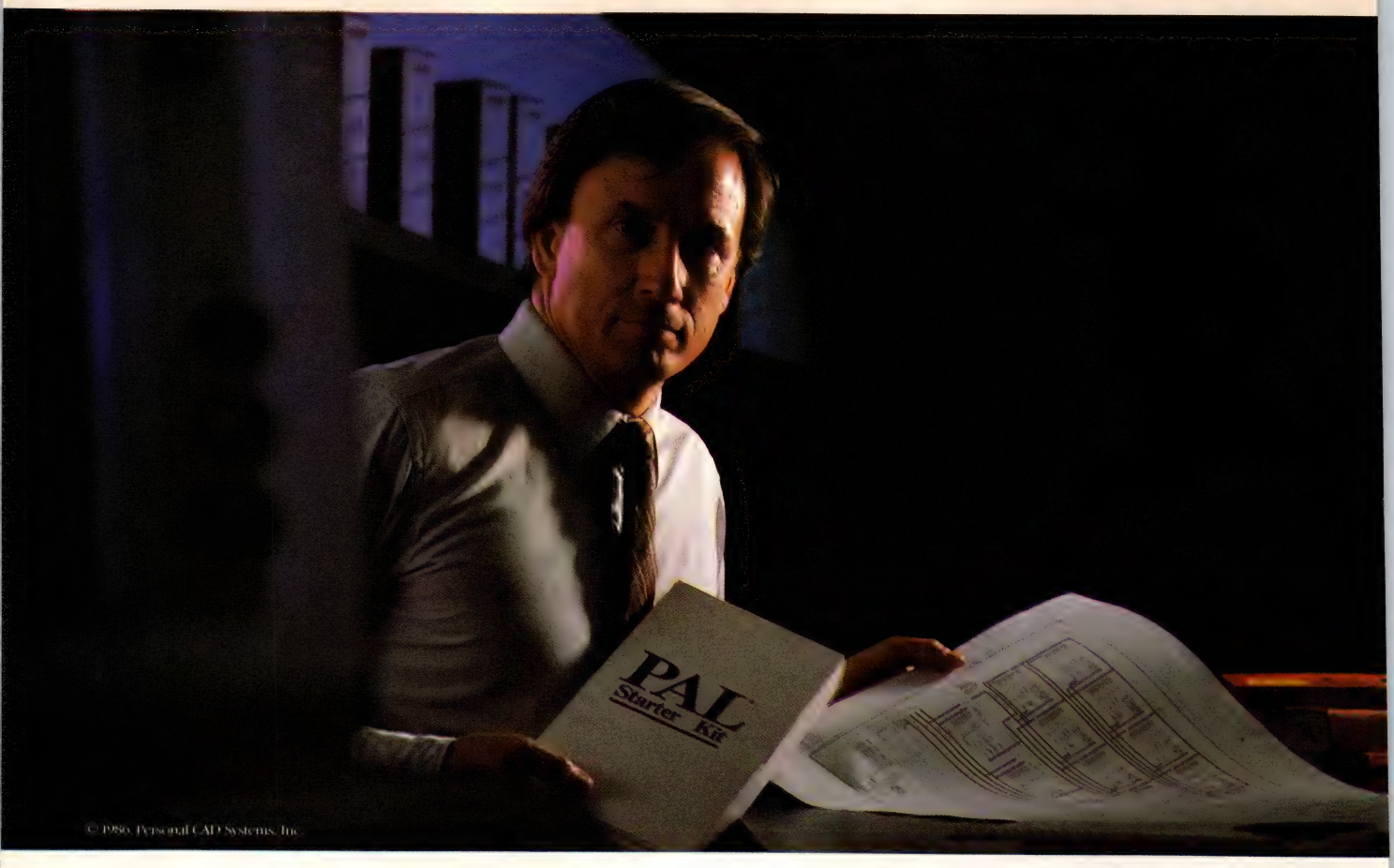
CIRCLE NO 59



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TI's IMPACT™ technology produces the fastest PAL devices you can buy: 12 nanoseconds fast. They can cut processing time in half for such speed-critical applications as high-resolution graphics. The Starter Kit includes one each of the TIBPAL16XX-12 series: the industry standards 16L8, 16R4, 16R6, and 16R8. Just one of these PAL functions can replace up to 10 TTL packages.

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NEW PRODUCTS

SOFTWARE

EDITING TOOL

- *Formats bibliographic references in one of 15 styles*
- *Runs on IBM PC family*

Designed as a tool for preparing and formatting bibliographic references, the Editor formats references in any one of 15 styles. In addition to using the formats provided, you can design your own style by entering new bibliographic data at the keyboard or importing existing data from files generated by other software. The program lets you design the page layout and specify printing details. Its five sort options include author sorts in chronological and reverse chronological order. If you embed full and abbreviated references in a manuscript prepared with a word processor, the bibliographic program will sort the bibliography in the order in which you cited the references. Styles supplied with the program include those of the American Medical Association, the American Psychological Association, the Council of Biology Editors, and the editors of *Nature* and *Science*. The program runs on the IBM PC, PC/XT, PC/AT, and compatibles. $399.

Institute for Scientific Information, 3501 Market St, Philadelphia, PA 19104. Phone (215) 386-0100.

Circle No 405

WINDOW INTERFACE

- *Provides user-defined function keys*
- *Lets you create menus, submenus, and help files*

The Commander program gives you multiwindow access to as many as 253 applications with a single keystroke on an IBM PC or one of its compatibles running DOS 2.0 or higher. The software performs this function by assigning a single function key to replace a complicated sequence of DOS commands. You can create menus, submenus, and help files within on-screen windows. The program also enables system integrators to configure access for a range of business requirements. The program can run on PCs having 128k bytes of memory; it requires two floppy disks or one hard disk and one floppy disk. $49.95.

Keyword Office Technologies Inc, 2816-11 St NE, Calgary, Alberta, Canada T2E 7S7. Phone (403) 250-1770.

Circle No 406

ANALOG SUPPORT

- *Provides assembly-language subroutines*
- *Lets you call subroutines from high-level application programs*

The PCI-20046S-1 Basic language package provides you with high-level access to this vendor's PCI-20000 system for data acquisition, test, measurement, and control products; the program is compatible with IBM PC-DOS 2.0 or higher. The program provides assembly-language subroutines that perform all major functions of the PCI-2000 system. You can call these subroutines from application programs written in Basic or other high-level languages or from assembly-language programs. The procedures that you can call include utilities, configuration procedures, file reads and writes, and error checking. The thermocouple subroutines provide RTD linearization as well as cold-junction compensation for J, K, and T thermocouples. All the subroutines are optimized for speed; using selected PCI-20000 system hardware, you can take as many as 89k readings/sec, according to the manufacturer. $225.

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 407

PLOTTING PROGRAM

- *Plots graphs independently or interactively*
- *Puts as many as six curves from different files onto one graph*

The Plotter Driver Program (PDP) creates multicolor scientific and financial graphs on pen plotters. You can enter data manually or use Lotus 1-2-3, this company's VP-planner, or other programs. You can plot as many as six curves from different files onto the same graph; each curve can contain as many as 1000 data points. The program is menu-driven and interactive; you can, however, opt to have the program plot graphs automatically and independently. The program works with two independent Y-axes. Each axis can be linear or logarithmically scaled with either forced or automatic scaling. You can label the three axes, the graph, and each plot. On single-pen plotters, the program waits for you to change pens between plots, axes, and labeling; on multipen plotters, the program changes pen colors automatically. The program can draw legends on each data point. It can mix dotted, dashed, or solid lines on a single graph. You can choose to draw full grid lines, or you can mark the axes at intervals of 2, 4, 10, or 12 divisions. You can specify any number of logarithmic divisions. The program runs on PC-DOS, MS-DOS, or CP/M-80 systems. $72.95.

BV Engineering, 2200 Business Way, Suite 207, Riverside, CA 92501. Phone (714) 781-0252.

Circle No 408

COMPUTER/UPS LINK

- *2-way communication between Unix/Xenix computers and UPS*
- *Operates with vendor's 15-kVA uninterruptible power supplies*

Datasave software, which provides 2-way communications between a computer and this company's Fer-

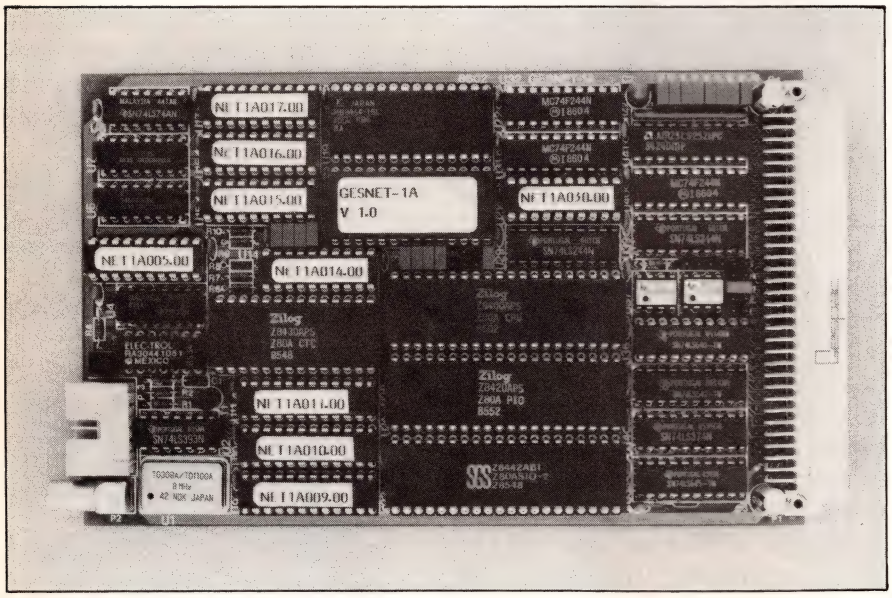
rups uninterruptible power supply (UPS), now operates with the Compaq DeskPro, Sperry IT, and other computers running Unix or Xenix. The software also operates with all the vendor's UPS units that supply 15 kVA or less. The software originally linked the IBM PC, PC/XT, PC/AT, and compatibles with 250- or 500-VA UPS units. The package displays line-power status, including voltage, current, load, backup time available, ambient and heat-sink temperatures, and battery voltages. The software also maintains a log of all power outages and displays this log upon request. When a power failure occurs, the system informs you of the estimated backup time. The μP built into the UPS calculates this time on the basis of load level, battery voltage, and battery capacity. In the case of extended power failure at an unattended computer (such as at a remote site or during an overnight run), the system will shut down running programs, save data, close files, and direct an organized cessation of operations. It will also shut itself down. When the ac line power returns, the UPS system automatically reboots the host computer and starts recharging the batteries. $50.

Best Power Technology Inc, Box 280, Necedah, WI 54646. Phone (800) 356-5794; in WI, (608) 565-7200.

Circle No 409

NEW PRODUCTS

INTERNATIONAL



LAN INTERFACE

- *Controller lets LAN transmit packets of any size to 1 km*
- *Provides transmission rates to 800k bps*

The Gesnet-1A board for G96-Bus computer systems is a Z80A-controlled LAN controller that handles the four lowest layers of the OSI (Open Systems Interconnection) model for data transmission on CSMA/CA networks. To control a network, the board uses a standard coaxial cable that operates in baseband NRZ mode at a rate of 800k bps. In CSMA/CA mode, the LAN can transmit data packets of any size between as many as 50 stations over as much as 400m of cable. When it's not in the collision-avoidance mode, the LAN can transmit data over as much as 1 km. To maintain the real-time flow of data packets and to cope with any packet size, the controller performs transparent accesses directly to host memory. The board includes carrier detection, collision detection, CRC code generation/check logic, a programmable clock generator that provides transmission rates of 100k, 200k, or 800k bps, and a coaxial-cable transceiver. SFr 2000.

Gespac sa, 3 chemin des Aulx, 1228 Plan-les-Ouates/Geneva, Switzerland. Phone (022) 713400. TLX 429989.

Circle No 410

Gespac Inc, 100 W Hoover Ave, Mesa, AZ 85202. Phone (602) 962-5559.

Circle No 411

VME BUS PASCAL-2

- *Runs on 68000/68010-based systems*
- *Includes source-level interactive debugger*

The SYS68K/Unix-Pas software package is an implementation of the Pascal-2 compiler from Oregon Software (Portland, OR) that runs on this company's 68000- and 68010-based VME Bus computer systems, which run Unix System V. The compiler conforms to the ISO-7185.1 standard and includes a source-level interactive debugger, a Pascal-2 profiler that can identify program bottlenecks, a source and text formatter, and a cross-reference generator and dynamic string library. The compiler is fully integrated with the operating-system tools provided on the company's Microforce computer systems. DM 1990.

Force Computers GmbH, Daimlerstrasse 9, 8012 Ottobrunn/Munich, West Germany. Phone (089) 600910. TLX 524190.

Circle No 412

Force Computers Inc, 727 University Ave, Los Gatos, CA 95030. Phone (408) 354-3410.

Circle No 413

RELAY DRIVERS

- *Drivers reduce component count*
- *On-chip protection functions*

The L9305 and L9306 dual-relay drivers are suitable for controlling other loads, including small dc motors and lamps. Each device contains two separate drivers made up of a comparator with hysteresis, an open-collector output stage, an output clamping zener, and an output current-limit circuit. Housed in a 16-pin PowerDIP (a copper leadframe plastic DIP in which eight pins on one side provide heatsinking for the die), the L9305 can deliver 1.5A per driver. The L9306, which comes in a miniature DIP, delivers 600 mA per driver. L9305 $1.15 (1000); L9306 $0.90 (1000).

SGS-Ates, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 414

SGS-Semiconductor Corp, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100.

Circle No 415

FSK RECEIVER

- *Specs 4-mW typ operation*
- *Accepts 200-MHz carrier frequencies; has 200-nV sensitivity*

The SL6637 is a single-chip direct-conversion radio receiver that receives frequency-shift-keyed (FSK) data transmissions at rates as high as 1200 bps. The device accepts an RF input and contains all the circuit elements required to decode the signal into a data output. You can use the receiver with carrier frequencies as high as 200 MHz; it has a typical sensitivity of 200 nV. Also included in the device is a low-battery detection circuit and a beeper driver. The SL6637 operates from a split supply: One side of the supply can be between 0.9 and 3.5V, and the other can be between 1.8 and 3.5V. For operation from a single low-voltage cell, an on-chip voltage reference and comparator allow you to control an external dc-dc converter. The SL6637 is available in a 44-position LCC or in a plastic quad J-lead package. £3.05 (50,000).

Plessey Semiconductors Ltd, Cheney Manor, Swindon, Wilts SN2 2QW, UK. Phone (0793) 36251. TLX 449637.

Circle No 416

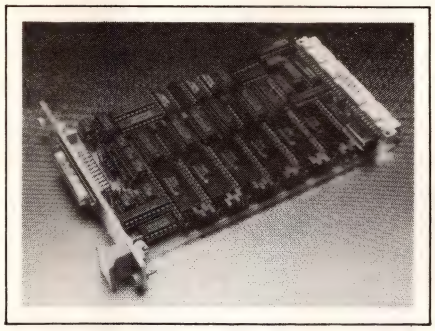
Plessey Semiconductors, 3 Whatney, Irvine, CA 92718. Phone (714) 951-5212. TWX 910-595-1930.

Circle No 417

ENCODER BOARD

- *Offers six independent input channels*
- *Each input channel has two optically isolated inputs*

The PVM single Eurocard position/velocity sensor board operates on the company's intelligent I/O channel sub-bus for VME Bus systems. It has six independent input channels, each of which is capable of 16-bit resolution. You can select the channels by jumper to perform direction discrimination, frequency measurement, pulse-width measurement, or up/down counting. You can cascade channels to provide resolutions as high as 96 bits, and you can synchronize the operation of different channels. Each channel has two optically isolated inputs, which let you perform direction determination by comparing the two input signals. Each channel can count at frequencies as high as 5 MHz, measure pulse widths as short as 333 nsec, or measure frequencies as high as 3 MHz. The board generates I/O-channel interrupts that occur on event- or counter-overflow/underflow conditions, but you can disable these interrupts on an individual-channel basis. DM 1980.



Pep Elektronik Systeme GmbH, Am Klosterwald 4, 8950 Kaufbeuren, West Germany. Phone (08341) 8974. TLX 541233.

Circle No 418

Pep Modular Computers Inc, 600 N Bell Ave, Pittsburgh, PA 15106. Phone (412) 279-6661.

Circle No 419

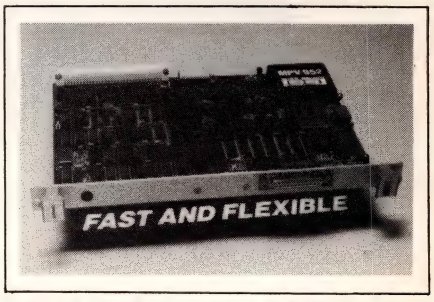
LOWPASS FILTER

- *Fifth-order lowpass Cauer filter*
- *Offers continuous-time operation*

Employing a transconductance-amplifier technique, the WM3015 continuous-time filter IC is a tunable, fifth-order lowpass Cauer filter, which doesn't suffer from the aliasing problems encountered with switched-capacitor types. By adding three external resistors, you can tune the filter's cutoff frequency over the 10- to 100-kHz range. The cutoff frequency has a typical temperature coefficient of 300 ppm/°C. The filter handles input signals as high as 4.5V p-p, and it has a typical insertion loss of −0.5 dB. Output noise is 0.6 mV rms typ. With a 10 kHz, 3V p-p input, the filter typically introduces 0.05% harmonic distortion. The WM3015 operates from a ±2.5 or ±3V supply and dissipates 22 mW typ. It comes in a 68-pin ceramic LCC. £55.

Wolfson Microelectronics Ltd, Lutton Ct, Bernard Terrace, Edinburgh EH8 9NX, UK. Phone 031-667 9386. TLX 727659.

Circle No 420



VME BUS A/D BOARD

- *Offers throughput rate of 330k samples/sec*
- *Operates from internal or external trigger source*

The MPV952 is an 8-channel, 12-bit A/D card for VME Bus systems that has a throughput rate as high as 330k samples/sec. The board has input ranges of 10, ±5, and ±10V, and a system accuracy of 0.05%. An onboard 32k-byte RAM, arranged as two swinging data-storage buffers, allows you to transfer the contents of one buffer over the VME Bus while the other continues to capture A/D converter samples. You can program the size of the data block to be captured, the number of sampled channels, and the sampling rate in 1-μsec increments between 3 and 256 μsec. You can operate the MPV952 in a continuous sampling mode from an internal or external trigger source. Alternatively, you can use an event trigger that initiates internal trigger sampling when an external event occurs. $2423 (10).

Burr-Brown Ltd, Simpson Parkway, Kirkton Campus, Livingston,

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The one name for your every application.

Each new day brings an accelerated demand for greater switching power supplies and increased miniaturization of electronic equipment.

To meet these diverse needs Tokin constantly adds to its extensive lineup of high performance ferrite cores for switching power supplies. In fact, Tokin ferrites come in a superwide range of frequency applications from 25kHz . . . all the way up to 500kHz.

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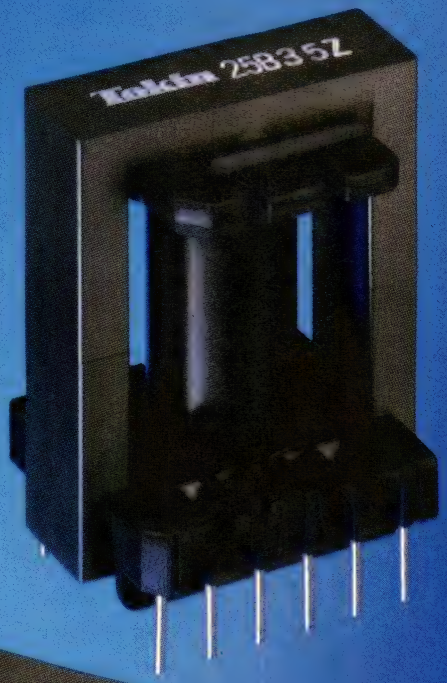
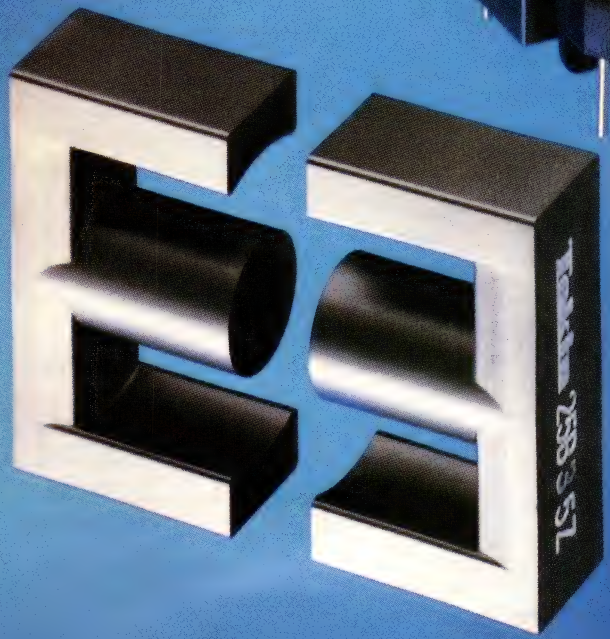
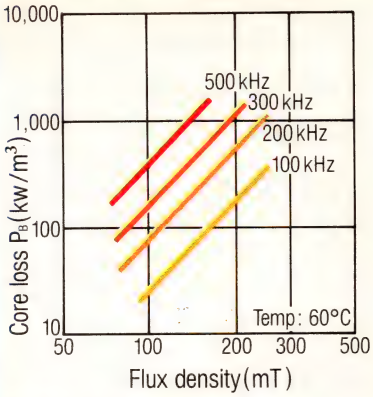




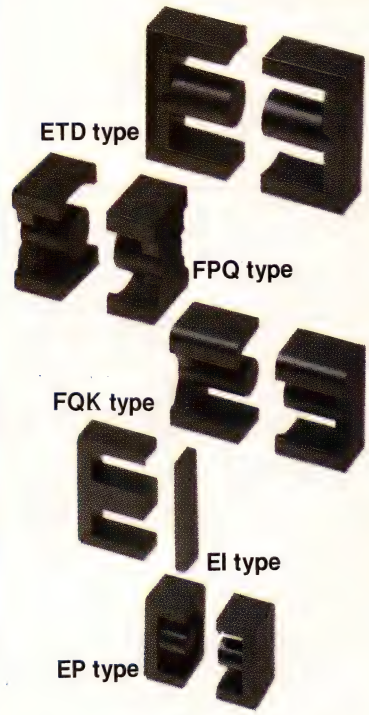
Core Loss vs. Flux Density(2500B3)



Material Characteristics

Material			2500B	2500B2	2500B3
AC initial permeability	μiac		2500±20%	2500±20%	2000±20%
Effective saturation magnetic flux density*	Bms	20°C mT	490	500	500
		100°C mT	380	380	380
Effective retentivity	Brms	20°C mT	100	130	80
		100°C mT	80	65	60
Effective coercivity	Hcms	20°C A/m	15.9	15.1	15.1
		100°C A/m	11.1	8.7	7.9

*15 Oe (Approx. 1,200 A/m)



Tokin

Tokin Corporation

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2261 Fortune Drive, San Jose, California 95131
U.S.A. Tel.: 408-946-4887

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CIRCLE NO 55

West Lothian EH54 7BG, UK. Phone (0506) 414445. TLX 727484.

Circle No 421

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111.

Circle No 422

ROTARY SWITCH

- *2- or 3-throw switches*
- *Switches mount on pc board*

RTE Series rotary DIP switches are available in spdt or sp3t versions. Each switch has a screwdriver-slot actuator; different versions of the switch allow screwdriver access from the top or bottom of the switch housing. The units can switch voltages between 2 and 50V dc, and currents between 1 and 100 mA. Their mechanical and electrical lifetime at the maximum switch-power rating of 0.5W is 2000 operations; over this lifetime, the switches spec 100-mΩ max contact resistance. RTE Series switches are suitable for use with automatic insertion equipment and with cleaning solvent. From FFr 1.75 to FFr 2.25 (10,000).

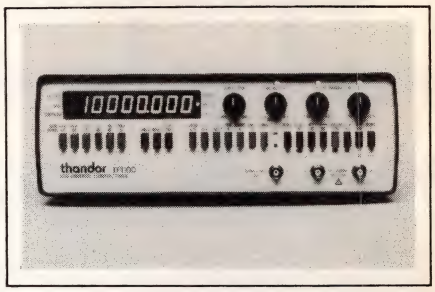
ITT Commutateurs et Relais, 157, rue des Blains, 92220 Bagneux, France. Phone (1) 46 65 85 55. TLX 260712.

Circle No 423

COUNTER/TIMERS

- *Channels operate to 100 MHz*
- *Additional input channel operates over 70-MHz to 1-GHz range*

The TF1000 and TF1100 benchtop counter/timers have A and B input channels that are capable of operating at frequencies as high as 100 MHz. The TF1100 has an additional C input channel that can operate over a 70-MHz to 1-GHz range. Both instruments have frequency,



period, period-average, time-interval (A to A or A to B), time-interval-average (A to A or A to B), frequency-ratio (A/B), and total-count measurement modes. The A- and B-channel inputs have ac or dc coupling, slope selection, ×1 and ×10 attenuators, and variable-level trigger controls. The A channel also features a switchable high-frequency filter. TF1000 £495; TF1100 £595.

Thandar Electronics Ltd, London Rd, St Ives, Huntingdon, Cambs PE17 4JH, UK. Phone (0480) 64646. TLX 32250.

Circle No 424

POWER SUPPLY

- *30W switchers come in 2- or 3-output versions*
- *Switchers let you select line-operating voltages of 115 or 230V*

The SA30 line of 30W open-frame, switch-mode power supplies includes 2- and 3-output versions. The 2-output version delivers 5V at 2A and 12V at 2A. Two 3-output versions are available: One provides 5V at 2A, 12V at 2A, and −12V at 0.3A; the other delivers 5V at 2A, 15V at 1.8A, and −15V at 0.5A. A jumper allows you to select line-operating voltages of 115 or 230V at 47 to 400 Hz. SA30 supplies carry safety approvals from UL, CSA, and VDE and meet international RFI and EMI standards. 2-output version, £21.43; 3-output versions, £22.50 (100).

Astec Europe, 8b Portman Rd, Reading, Berks RG3 1EA, UK. Phone (0734) 509411. TLX 848047.

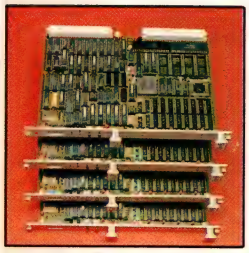
Circle No 425

THE HI-PERFORMANCE PEOPLE

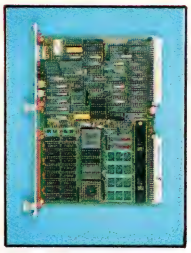
ELECTRONIC MODULAR SYSTEMS INC.

VMEbus Central Processors

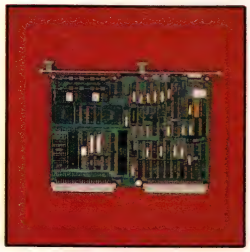
REAL TIME APPLICATIONS



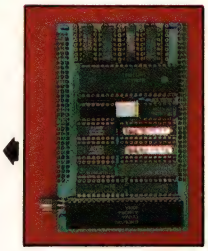
CPU-2RT



CPU-2SC



CPU-2PB



PIGGY BACK BOARDS

68020
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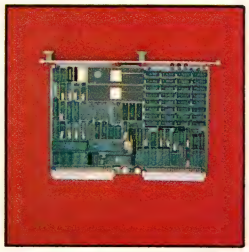
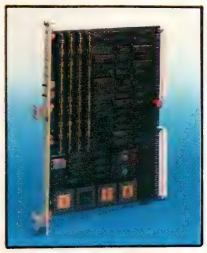
16.5 MHz, or
20 MHz,
DRAM ¼ Mb,
1 Mb, or 4 Mb

CPU-4RT

STAND ALONE HOST



CPU-1



CPU-3

	STAND ALONE HOST		REAL-TIME MASTER/SLAVE			
	CPU-1	CPU-3	CPU-2RT	CPU-2SC	CPU-2PB	CPU-4RT
MICROPROCESSOR	68000/68010	68010	68000/68010	68000/68010	68000/68010	68020
FREQUENCY	8MHz	12.5 MHz	12.5 MHz	12.5 MHz	12.5 MHz	12.5 - 20 MHz
MEMORY MANAGEMENT	68451	68451 (2nd as option)				
DMA	LOGIC		68450 option	68450 option	68450 option	
FLOATING POINT PROCESSOR		68881 (option)			68881 (option)	68881 (option)
RAM (DUAL PORTED)	256 Kb	2 Mb	128/512 Kb	128/512 Kb	512 Kb	1/4, 1, 4 Mb
EPROM		2 Sockets (128 Kb)	2 Sockets (128 Kb)	2 Sockets (128 Kb)	2 Sockets (128 Kb)	2 Sockets (128 Kb)
EEPROM			2 Sockets (16 Kb)	2 Sockets (16 Kb)		
SIO	1 PORT	1 PORT	2 PORTS	4 PORTS	• I/O ON PIGGYBACK BOARDS • PB-SCSI1 SCSI/DMA • PROTO BD	3 PORTS
PIO	1 PORT		1 PORT			
TIMERS	1	4/ 8 bit	3/ 16 bit			1/ 32 bit
ADDITIONAL FEATURES	1K PROM FLOPPY DISK CONTROLLER	Translation Cache	R/T CLOCK 58274	R/T CLOCK 58274		
SOFTWARE	UNIX* SYS V	UNIX* SYS V pSOS**	pSOS** PDOS***	pSOS**	pSOS**	pSOS** PDOS***

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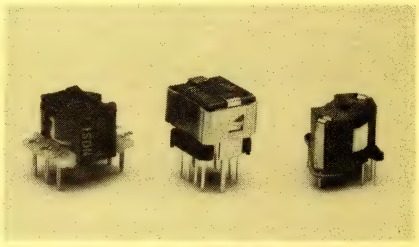

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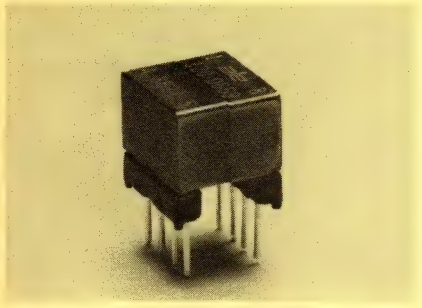

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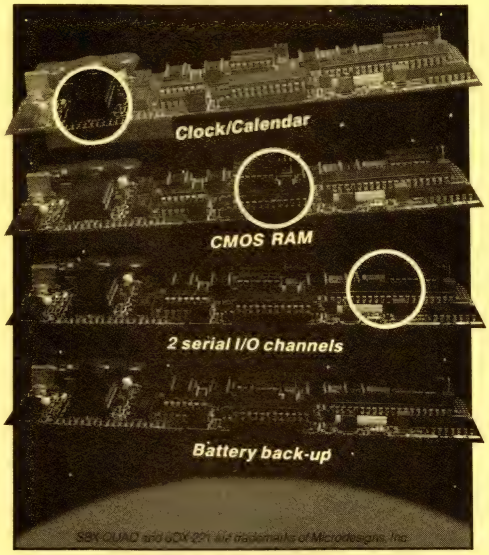

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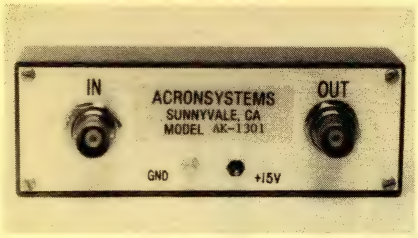

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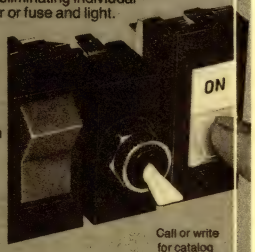

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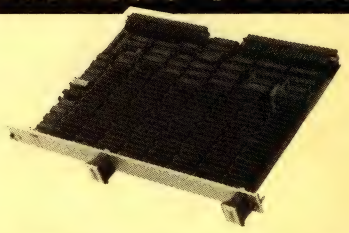

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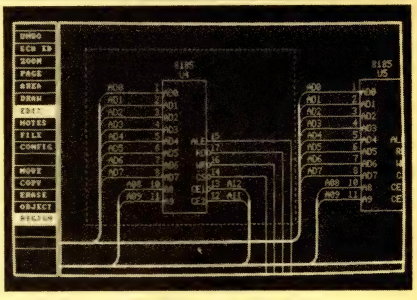

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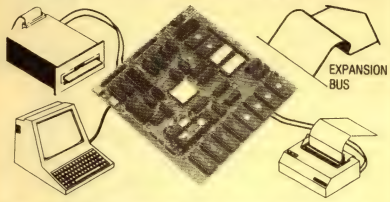

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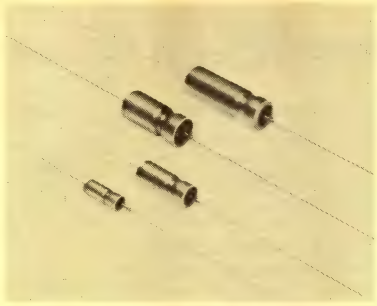

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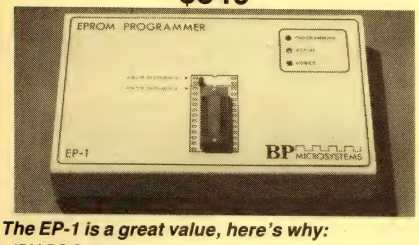

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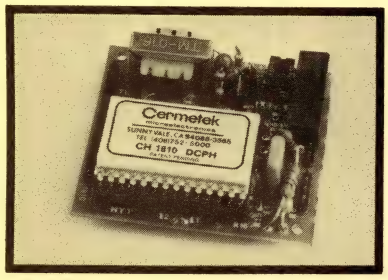

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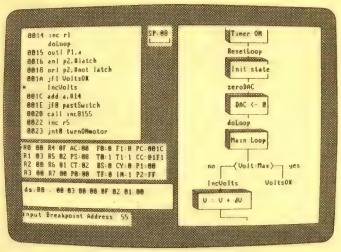

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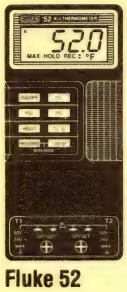

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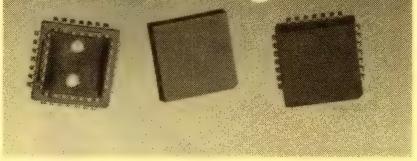

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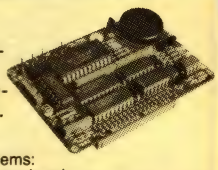

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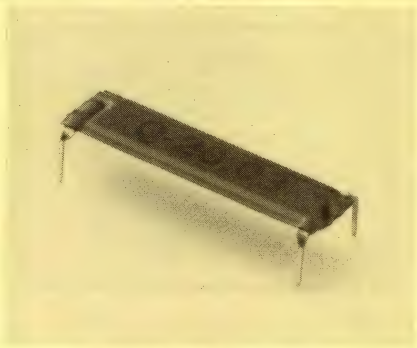

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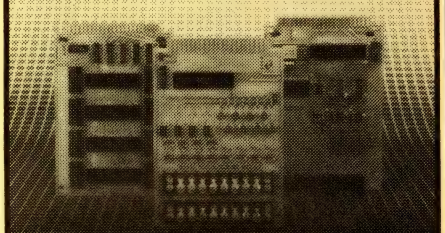

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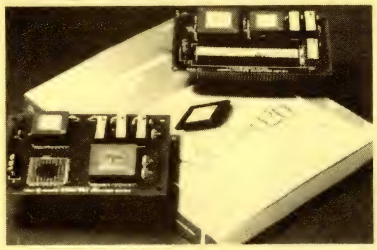

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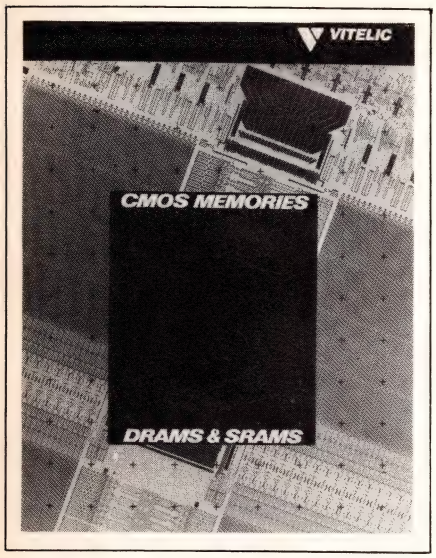

Catalog on static, dynamic RAMs

This catalog describes the specifications of the manufacturer's line of CMOS dynamic and static RAMs. The 98-pg document details 64k-, 256k-, and 1M-bit dynamic-RAM devices, as well as 8k-, 16k-, and 64k-bit static-RAM chips.

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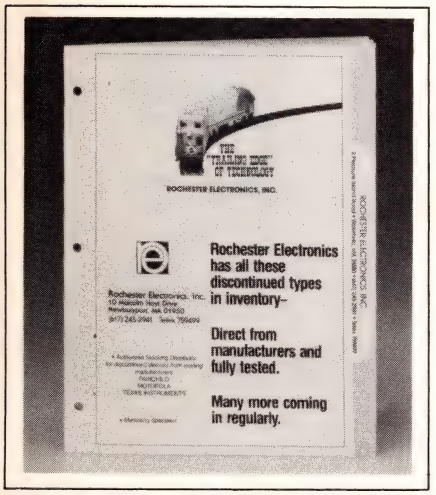

Guide lists discontinued ICs

This edition of the distributor's catalog of discontinued ICs lists over 3000 components from such manufacturers as Fairchild, Motorola, and Texas Instruments. The 20-pg guide covers an inventory of more than 50 million devices, all of which are available from stock and in quantity. Among the product types listed are DTL, RTL, TTL, 74H, and 54H devices, as well as Motorola's MECL and SUHL parts. You can request regular updatings of the catalog, which the distributor issues periodically.

Rochester Electronics, 10 Malcolm Hoyt Dr, Newburyport, MA 01950.

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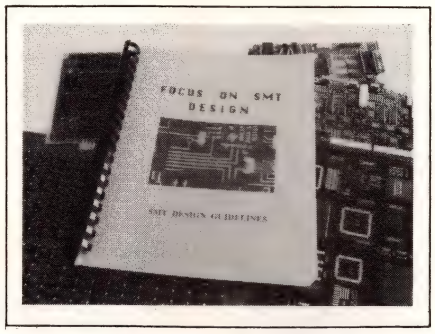

Book addresses surface-mount technology

Focus on SMT Design is a 190-pg, spiral-bound book containing data on SMT (surface-mount technology) board layout and design for military and commercial applications. Including over 30 tables and 70 photos and drawings, the guide covers standards, pad geometries, spaces and line-width rules, layout rules, thermal considerations, and design for manufacturing, test, and repair. It also has a dictionary with nearly 2000 entries. $195; the publisher will issue quarterly updates for $1 per page.

Anatrek, Box 780, Santa Barbara, CA 93102.

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Guide helps in selecting semiconductors

This 202-pg selection guide covers all of the manufacturer's products, including standard and semicustom logic, 16-bit microcontrollers, 32-bit μPs, memories, signal-processing/telecommunications devices, linear circuits, small signal/discrete devices, power systems, and semiconductors. In addition to basic product features and specifications, the book includes information on packaging and ordering, a device cross-reference index, and a listing of the company's division locations, technology centers, and distributors. Dimensional drawings supplement the text.

Fairchild Semiconductor Corp, Box 1500, Cupertino, CA 95014.

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Catalog covers enclosures, stampings, and assemblies

This 66-pg spiral-bound catalog lists the company's line of deep-drawn metal enclosures, stampings, and assemblies. The booklet also features military cases and covers per MIL-T-27 specifications as well as crystal and miniature-relay housings. A metric conversion table and a chart of standard modifications provide convenient reference aids.

Hudson Tool & Die Co, 18 Malvern St, Newark, NJ 07105.

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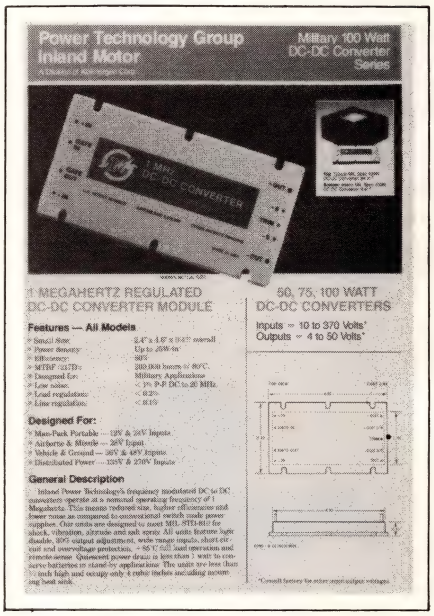

Military converters spec'd

A series of military 100W dc/dc converters is the subject of this 6-pg brochure. It focuses on the reduced size, higher efficiencies, and lower noise of the 1-MHz frequency-modulated converters as compared with

conventional switch-mode supplies. The brochure outlines input- and output-voltage selections and corresponding dc/dc-converter model numbers, and it contains a power-booster selection chart with specifications for increased output power to 1.8 kW.

Inland Power Technology, 4020 E Inland Rd, Sierra Vista, AZ 85635.

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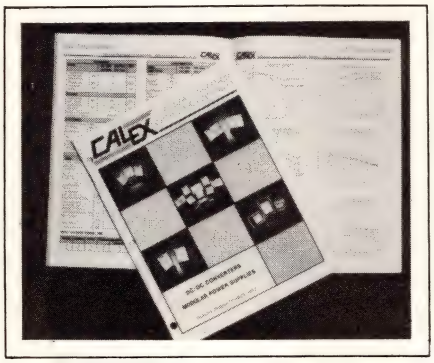

Design guide details power converters, supplies

This manufacturer's power-conversion design guide and catalog contains data on more than 90 dc/dc converters and 50 ac/dc encapsulated, modular power supplies. The 64-pg publication offers electrical and mechanical specifications, design curves, and prices for all products discussed; it devotes eight pages to application notes. The 3-hole-punched guide also contains pictures, dimensional drawings, and graphs.

Calex Mfg Co Inc, 3355 Vincent Rd, Pleasant Hill, CA 94523.

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Brochure reviews surface-mounting methods

Surface Mounting Today (#81409), a 16-pg brochure, begins with an overview of the limitations and capabilities of surface-mounting methods. It discusses housing materials, lead shapes, and designing for solder-joint reliability. In addition, it covers the characteristics that affect product performance and effective testing strategies as they relate to the company's surface-mount products. Descriptions of typical surface-mounting interconnection parts include DIP and chip-carrier sockets, subminiature D connectors, pc-board connectors, and 0.025-in. square-pin headers. Four-color photos and drawings supplement the descriptions.

AMP Inc, Box 3608, Harrisburg, PA 17105.

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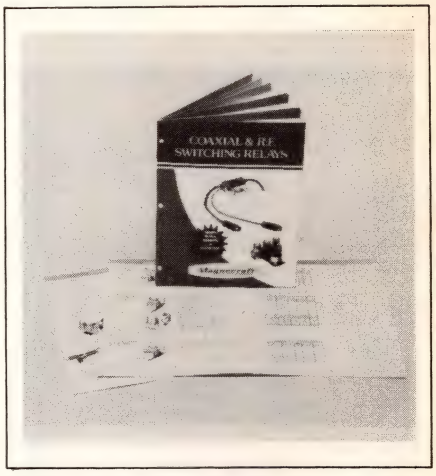

Update on switching relays

This catalog contains information on different types of coaxial relays, which feature time-delay auxiliary contacts and ac and dc operation. The booklet also highlights unshielded RF switching relays. It is 3-hole punched for loose-leaf filing.

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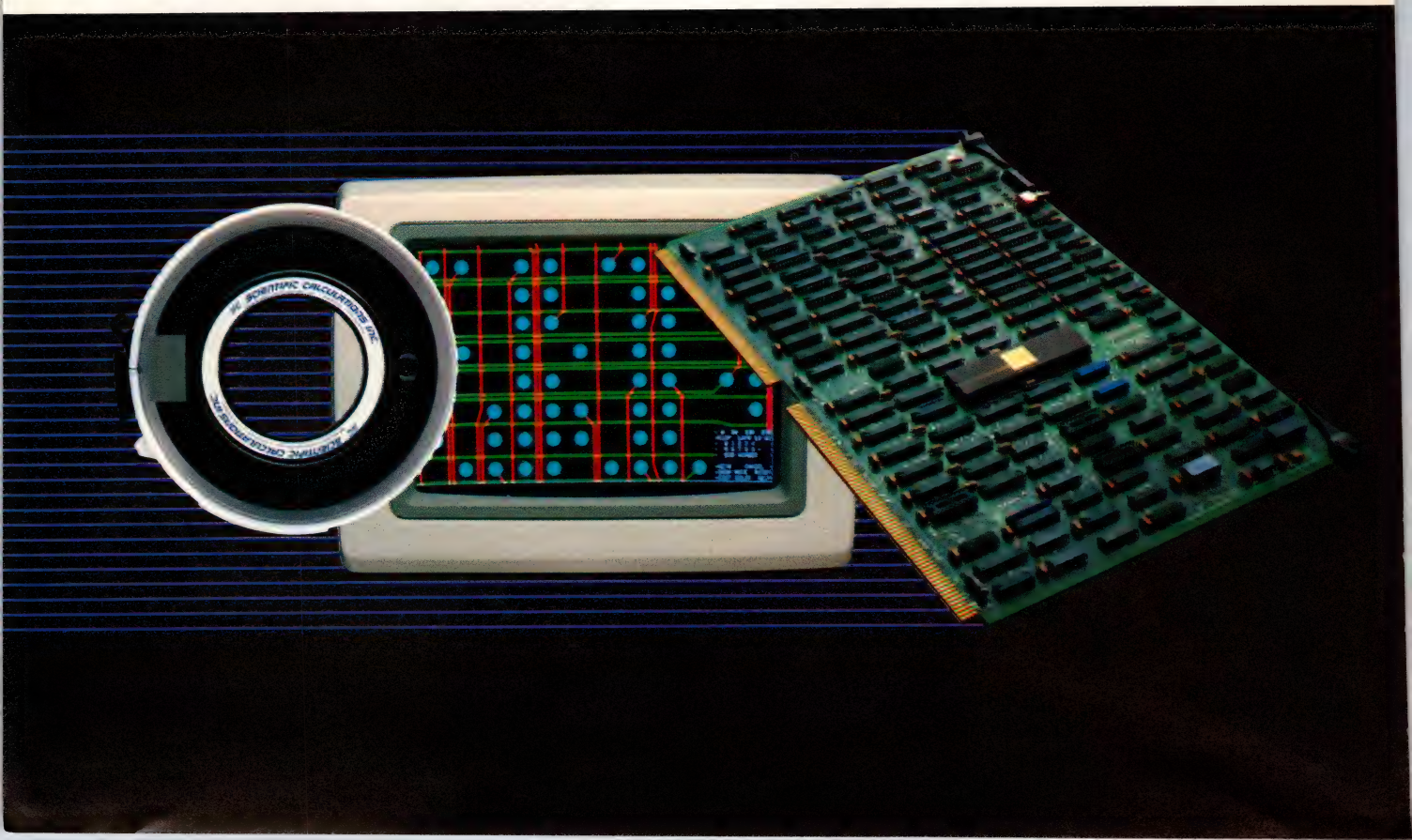
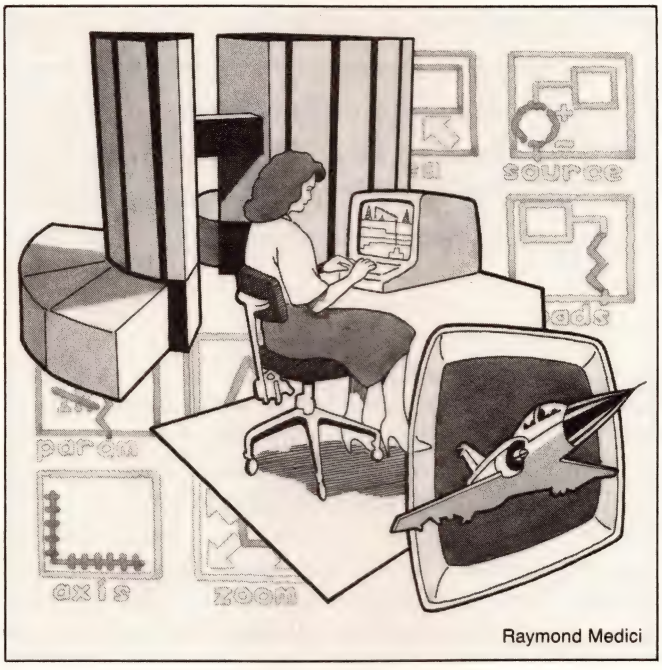


Industry needs design-automation experts to unleash the power of supercomputers

George Stubbs, *Staff Editor*

From the design of products to the discovery of physical phenomena, supercomputers are the stars of modern research and development. Many people regard the power of these machines as vital to basic research, to the competitive stance of manufacturers across a broad range of industries, and to the US's position as a leader in science, technology, and commerce. Yet the full power of the supercomputer may, for a short time anyway, remain just beyond the reach of US scientists and engineers, as a short supply of design-automation experts struggles to render applications code in forms that can take the most advantage of the machines.



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To some, the term "supercomputer" simply means the most powerful machine on the market. A more specific definition describes today's low-end supercomputer as a machine that can perform at least 100M flops (floating-point operations per second). Theoretical upper limits are harder to pinpoint. Systems that boast of 1G- to 10G-flops performance are appearing. Floating Point Systems Inc is reported to have recently engineered a "massively parallel" supercomputer, based on Inmos Transputer chips, that can perform 262G flops.

These levels of performance are possible because the processing techniques depart from the serial, or scalar, type of processing common in previous computers. The new machines perform vector processing—the simultaneous manipulation of matrices of numbers, which are common to large-scale scientific and engineering applications. Parallel-processing systems carry simultaneity a step further, partitioning several portions of an application among a number of processors. So-called massively parallel systems combine anywhere from eight to several thousand processors in a single computing system.

As is often the case with any new technology, government applications have been the driving force behind the expansion of computing power. Investigations in space and aeronautics, advanced cryptoanalysis, weapons simulation, and other specialized areas demand the kind of complex computations that only supercomputers can handle in a reasonable amount of time (hours vs years). University research centers have also conducted high-level scientific research using supercomputers, exploring atomic and nuclear physics, atmospheric science, materials science, and other areas in which the behavior of systems must be analyzed under complex, wide-ranging sets of conditions.

Now US industry is starting to appreciate the benefits supercomputing power can afford. "About three or four years ago, industry finally realized these machines are also very useful for some of the things they needed to do," says John Connolly, director of the National Science Foundation's Office of Advanced Scientific Computing. "If you have a computer that's 100 times faster than your smaller computer, then obviously you can get the job done in one-hundredth of the time."

"The job" is typically product design and simulation. The aerospace and automobile industries have been among the first to incorporate supercomputers into the production cycle. The machines help conduct aerodynamic tests on airplane and automobile designs, and the three major automakers are using supercomputers to conduct crash tests, among other tasks. Clearly, supercomputers can help cut costs by eliminating the need for expensive models and prototypes. But reduced design time is the big gain.

Streamlined design

All manufacturing industries stand to benefit from the application of supercomputers, for any maker of a product can stand to shrink major segments of the design cycle by

factors of 60 to 100. A report by Sanford Bernstein & Co, a New York City-based market-research firm, projects that the number of supercomputer sites will grow at a 60% compounded annual rate until the end of 1990. That growth is spurred largely by the US commercial sector.

Bernstein & Co researcher Rick Martin says that the semiconductor industry is poised to increase rapidly its use of the supercomputer. One of the first to make the investment, Fairchild Semiconductor, is using a Cray 1S in the design of application-specific integrated circuits (ASICs). And when one company in an industry takes such a major step in the realignment of its production facilities, others are bound to follow.

"Our customers are doing design tasks on [the Cray] when designing applications-specific technology," says Lanny Ross, general manager of Fairchild's Gate Array Div (Milpitas, CA). "Specific tasks are logic simulation, fault simulation, placement and routing, design-rule verification, net connectivity verification, Spice [circuit simulation], and fracturing data for pattern and tape generation." Ross reports that the Cray performs a simulation required for a 6000-gate array in about an hour, compared with about 60 hours on a VAX.

The conclusion one might draw from this promise of high productivity in US industry is that many of our problems in research and development will be solved by supercomputers, and many man-hours of work will be eliminated. Such a conclusion of course underestimates the ingenuity of government, university, and industrial researchers in their pursuit of new problems and areas of inquiry. It also obscures the fact that the transition to a supercomputer-based world of design automation will be anything but smooth.

By virtually all accounts, industry is facing a shortage of engineers who are qualified to exploit the full power of supercomputers. That does not mean, however, that all professional engineers and engineering students must now take courses in supercomputing. The chief conceptual hurdle is less a matter of making the US engineering population familiar with supercomputer architectures and programming techniques than it is one of ensuring that today's and tomorrow's engineers understand the process of simulation. On the basis of conversations with several employers, Rick Martin believes that most of today's engineering graduates are already thinking in terms of simulation, as opposed to model and prototype building.

All manufacturing industries stand to benefit from the application of supercomputers; any maker of a product would welcome a design cycle that's shorter by a factor of 60 to 100.

Most supercomputer end users will be conducting simulations with the help of existing design programs. The supercomputer's operation will be, for the most part, transparent to the user, though speed improvements will undoubtedly be noticeable. At Fairchild, for example, design engineers will work directly on VAX minicomputers, which in turn will queue jobs for treatment by the Cray 1S. For these design engineers, and those in other industries, work with supercomputers will require no radical retraining.

Building the simulators

However, someone must write the simulation programs and other tools that engineers will use, and here is where the shortages of qualified personnel will be most keenly felt. "The real issue is new systems software for these machines," says David Kuck, professor of computer science and director of the Center for Supercomputing Research and Development at the University of Illinois at Urbana-Champaign. "New compilers, new applications packages, library routines—in other words, things that many people can use . . . That's the area I think is in great need and is underfunded and undersupplied with people."

The people who write the systems software and applications packages must blend a unique combination of skills. First, the electrical engineer who creates a simulator for an ASIC, for example, must know how to design a circuit and how to write a computer program in, say, Fortran-77. This combination of abilities is not as rare as it used to be. Kuck, in addition to directing a major supercomputing research facility, runs a small company that produces compilers for supercomputers. He notes that a substantial number of job applicants come from areas other than computer science. Qualified programmers in a number of fields, he observes, are not that hard to come by.

It is, however, hard to find qualified programmers, in their respective fields, who understand the operating systems, compilers, and processing modes of supercomputers. The key to extracting improved productivity from a supercomputer lies in the ability to "vectorize" a simulation program—to know which parts of the simulation can be written in such a way that they make maximum use of the supercomputer's vector-processing capability. Consequently, the design engineer who creates the simulation for a given application must understand both the details of that application and the techniques of vector processing.

Lanny Ross says the supply of such talented people in the semicon-

ductor industry is limited. In his view, the tasks confronting these engineers aren't conceptually daunting, but they do take a long time to complete. "To do a good job on the simulator, a person may be tied up for two to five years—to write it, debug it, run it through the test stations, continue to enhance it, speed it up . . . It's almost a career, to develop and bring one of these major tools to maturity.

"I'm sure that the number of top people that are capable of writing [this] kind of very complex integrated-circuit simulator is few and far between," Ross continues. "It takes a 6- to 12-month recruiting effort to find someone, and then they will require some training."

Eventually, relief in this area should come from sophisticated programming tools that help automate the compilation and vectorization tasks and let the average programmer produce efficient code. In the meantime, however, US industry faces a kind of window of vulnerability. Those who are able to optimize code for execution on supercomputers are playing catch-up with the proliferation of the machines in industry and on university campuses.

By virtually all accounts, industry is facing a shortage of engineers who are qualified to exploit the full power of supercomputers.

The recent nationwide interest in supercomputing is no accident. In 1982, the *Report of the Panel on Large-Scale Computing in Science and Engineering*, sponsored by the NSF and the Department of Defense in cooperation with the Department of Energy and the National Aeronautics and Space Administration, charged universities, industry, and the appropriate federal agencies with the task of preserving the US's leadership in computer technology. To accomplish this goal, the report recommended the establishment of an interdisciplinary network of supercomputing facilities. The panel noted that the governments of West Germany, France, Great Britain, and, in particular, Japan were vigorously pursuing supercomputer research; a national program, implemented immediately, would keep the US engineering and scientific community current by providing access to supercomputing resources, underwriting research in software and algorithms, and expanding opportunities for training.

In keeping with these goals, the NSF in 1985 established national supercomputing centers at the University of Illinois at Urbana-Champaign, Cornell University, the University of California at San Diego, and the John von Neumann Center near Princeton, NJ. The San Diego and Princeton centers are each run by a consortium of schools. The NSF has since set up a fifth center in Pittsburgh, to be run by Westinghouse, Carnegie-Mellon University, and the University of Pittsburgh. Though it has underwritten the purchases of supercomputers at other universities, the NSF intends the five centers to form the nucleus of a national network that provides supercomputing facilities to engineers and researchers around the country.

Larry Smarr, professor of physics and astronomy at the University of Illinois at Urbana-Champaign, is director of one of the five NSF centers, the university's National Center for Supercomputing Applications. Smarr speaks often of the supercomputing "famine" at US universities. He sees the NSF program as a valuable resource in bringing together university and industry researchers. More important, he sees the program closing the gap between the current lack of experience with the machines and a future in which US engineers and scientists are well trained in the use of the new technology.

"We're setting up an interdisciplinary research center, a model comprehensive computer environment of workstations and personal computers networked to the supercomputer," says Smarr. "We have a national visitors' program, which should be able to handle 500 visitors per week who come here and live in this very rich environment." Visitors from industry and academia will work on their own problems at the center, learn more about what kinds of facilities can solve those problems, and return to their companies and universities with purchasing recommendations. "We are trying to make a one-stop shopping environment for national users," says Smarr.

"What I'm hoping to see over the next few years," Smarr says, "is that engineers appreciate just how complex and large-scale a problem these supercomputers can attack. And that they start attacking them . . . I think we're going to see a whole new generation of engineers who are trained in the new supercomputer centers, and they will simply take a quantum leap over their faculty advisers in terms of the ambition of their research goals."

Focus on problem solving

The centers' primary purpose is to provide scientists and engineers with the latest tools to attack complex problems, not to train them specifically in use of the supercomputers. The NSF does, however, sponsor intensive, 2- to 3-week summer courses on supercomputer use. Connolly expects the NSF to run six summer sessions this year, at Boeing Computer Services in Seattle, WA, the National Center for Atmospheric Research in Colorado, Cornell University, the University of California at San Diego, and the universities of Minnesota and Georgia. The courses are primarily for "the top research students in sci-

ence—the people who will get their PhDs and become professors and leading researchers in industry and government," says Connolly.

Getting the government to help universities establish and maintain supercomputing facilities on university campuses is a good first step, but it is only a first step. Supercomputers are expensive and represent only a small part of the cost of operating a supercomputing facility. Obviously, not every school with a heavy engineering or science orientation can afford one.

Providing access to existing supercomputer facilities via communication links to engineers and researchers around the nation is a far higher priority. Squeezing "the most science and engineering" out of available supercomputer cycles, as Smarr puts it, is foremost in the minds of NSF officials and the directors of the supercomputer centers. Thus far, networking has been a problem that has challenged the extremes of computer science.

"I think that a critical need is to break down a lot of the departmental barriers that currently separate supercomputer users from each other."—Professor Larry Smarr, University of Illinois.

Nontechnical barriers to efficient use of supercomputers also exist. Smarr underscores interdisciplinary work as a key to making optimum use of supercomputers. "Take an area like turbulence," he says. "There might be a dozen professors on a campus as large as ours who are pursuing it . . . One thing our center is trying to do is to bring those people together and let them share common technologies and solutions."

Obviously industry, too, has a stake in supporting university supercomputing facilities and expanding the pool of engineers who are experienced in the arts of simulation and vectorization. Smarr notes that one goal of his center is to bring industry researchers back to the university on a visiting basis to share their experience in state-of-the-art computing with students.

Control Data is one company that has gone a step further and set up a program of its own, the Engineering Center Network Program. The company, a traditional leader in advanced computing technology and majority owner of the supercomputer maker ETA Systems, has helped establish several centers on university campuses. Another goal is to expand cooperation between industry and academia. "The initial thrust of these centers was to focus not on supercomputing but on engineering applications in research and education," says Rex Krueger, Control Data's vice president of higher-education marketing. "We have 20 such centers right now, and we're in the process of linking them together." During 1986 and 1987, the company plans to install 10 Cyberplus parallel-processing computers in the network.

Human resources in transition

Industry can cooperate with the universities with an eye toward its future needs, but it has immediate problems to solve as well. To build the kind of simulators his company needs, says Fairchild's Ross, design engineers with an interest in design automation must leave behind the work they've been doing and concentrate on building the kinds of tools that will make other engineers' jobs easier. Ross believes that there's no one better qualified to build a new, automated design tool "than a person who has actually done the work previously in a manual, or semiautomatic, mode."

Indeed, as the computer industry well knows, transfer of personnel across career boundaries is the kind of unpredictable event that can smooth the transition to a new technology. In the recent past, legions of teachers and other professionals who saw their careers as dead ends became programmers and computer scientists and thus helped usher in the so-called Information Age. This time around, the conversion of experts in engineering and science into skilled applications programmers may be required to lead industry into the era of simulation.

Even if the government, industry, and academia succeed in improving access to supercomputers, it's still not clear whether such measures will be enough to help the US reassert its leadership in technology and commerce. The lack of sufficient manpower to apply supercomputers to all the disciplines and industries that can use them may only be part of a far larger problem: Will the whole pool of people trained in science and engineering be sufficient to meet society's needs?

"I'm confident that the pool of PhD-trained people is going to become more and more important to the future of the economy," says Kenneth Wilson, professor of physics at Cornell and director of the supercomputing facility at the university's Center for Theory and Simulation in Science and Engineering. "The economy will be limited if we don't keep that pool up to an adequate size, because industry is facing more problems that are going to require PhD-level competence if they're going to be solved. Increasingly, the areas that have to cope with that complexity will be using supercomputers to help solve those problems." **EDN**

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Sept. 18	Aug. 27	Personal Computer-Based CAE; Power ICs; Computer Peripherals; Hardware & Interconnection Technology; EDN 30th Anniversary Tribute	
Oct. 2	Sept. 11	Surface Mount Technology; Memory ICs; CAE; Semicustom IC Directory (CAE-related*)	Closing: 10/16 Mailing: 10/28
Oct. 16	Sept. 25	Digital Signal Processing; Personal Computers; ICs; Test & Measurement Instruments; Display Technology	
Oct. 30	Oct. 8	Batteries; Converters; Wescon '86 Product Preview; European Electronics; Computer Boards	

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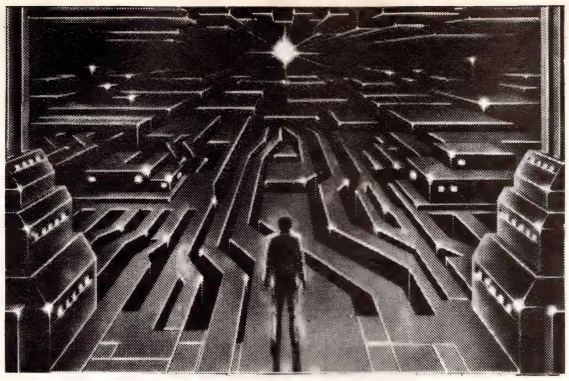

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LOOKING AHEAD

EDITED BY GEORGE STUBBS

Semiconductor industry to make gains through '87

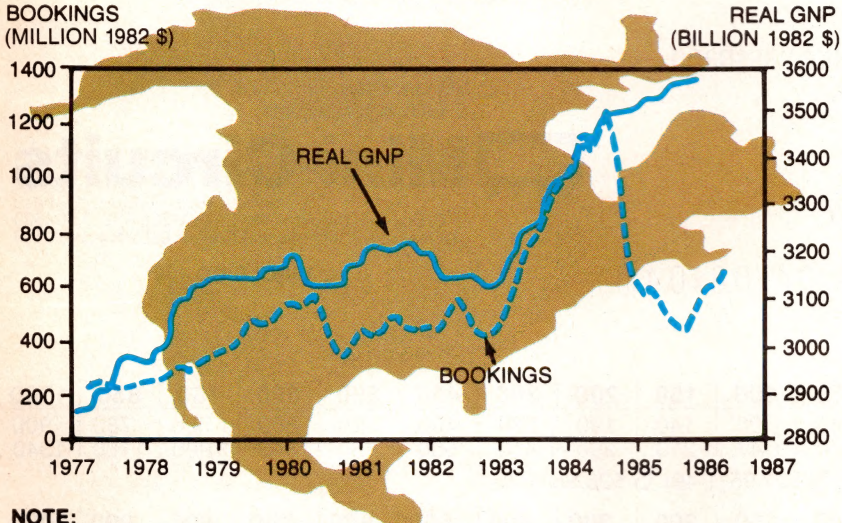
Although a pause in the current increase in bookings is possible, the market for semiconductors should continue its return to health for the remainder of this year and through the next. According to Salomon Brothers Inc, a New York City-based investment firm, the industry's recovery is contingent upon a revival of the overall US economy through the rest of 1986, but a number of factors are combining to make such an outcome a reasonable hope.

Salomon Brothers states that, historically, semiconductor industry fortunes have more closely tracked the Gross National Product than any other economic measure. The recession in the semiconductor industry that occurred in the last half of 1984 and the first half of 1985 departed from this pattern, indicating that the industry's woes were its own; excessive overbooking and inventory buildup led to those declines in sales and prices.

Salomon Brothers expects semiconductor bookings once again to match US economic performance as measured by the GNP, however. One of the factors that will help is the recent weakening of the US dollar overseas—particularly with respect to the Japanese yen—and a consequent renewal of interest in US-made products. Other developments that make the general economic picture look good are declining interest rates and energy costs.

Another factor that should help, says Salomon Brothers, is the US government's "increased sense of urgency" regarding the importance of the semiconductor industry to the US economy and the resolution of trade imbalances with Japan. Both the industry and the Reagan administration believe that aggressive action is required, and both have welcomed recent preliminary rulings from the Commerce Department, which has found that the Japanese have been dumping EPROMs and dynamic RAMs on the US market. Salomon Brothers doesn't believe that the resulting tariffs on Japanese ICs are the final solution to the problem, but it does regard them as a step toward pursuading the Japanese to open their markets to US goods.

US MONTHLY SEMICONDUCTOR BOOKINGS vs REAL GNP



NOTE:
BOOKINGS REFLECT ORDERS FROM US- AND EUROPE-BASED COMPANIES, 1977 TO 1986, AND JAPAN-BASED COMPANIES, 1984 TO 1986.

(SOURCE: SEMICONDUCTOR INDUSTRY ASSOCIATION)

Feds to enrich telecomm market by $3.9B in '90

The federal government's demand for telecommunications equipment and services will grow from 1985's $2.6 billion to $3.9 billion in 1990, according to Input, a Mountain View, CA, market research company that specializes in the computer and communications industries. The average annual growth rate in government expenditures through this period is 8%.

Outlays for network equipment and systems, including common-carrier, value-added, local-area, and wide-area networks, will constitute 87% of total expenditures. Purchases of transmission facilities such as cables, switching equipment, and satellite ground stations will be 8% of the total procurement. Professional services such as network design and equipment installation and maintenance will command 5% of the $3.9 billion. This last category—particularly in the form of maintenance contracts—will be the fastest growing sector of the government telecomm market (11% average annual growth).

The federal agencies demanding the largest shares of telecomm equipment and services are the Department of Defense and the General Services administration. The DoD will spend $1.8 million in 1986; the GSA will spend $728 million in the same year. Despite divestment and the move to new markets, AT&T remains the dominant supplier. According to Input, however, AT&T's former regional operating companies will not be a force in the federal telecomm market in the next few years.

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Pass Band (MHz)	start, max.	41	90	133	185	290	395	500	600	700	780	910	1000
	end, min.	200	400	600	800	1200	1600	1600	1600	1800	2000	2100	2200
Min. 20dB Stop Frequency (MHz)		26	55	95	116	190	290	365	460	520	570	660	720

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*Prefix P for pins, B for BNC, N for Type N, S for SMA *example:* **PLP-10.7**

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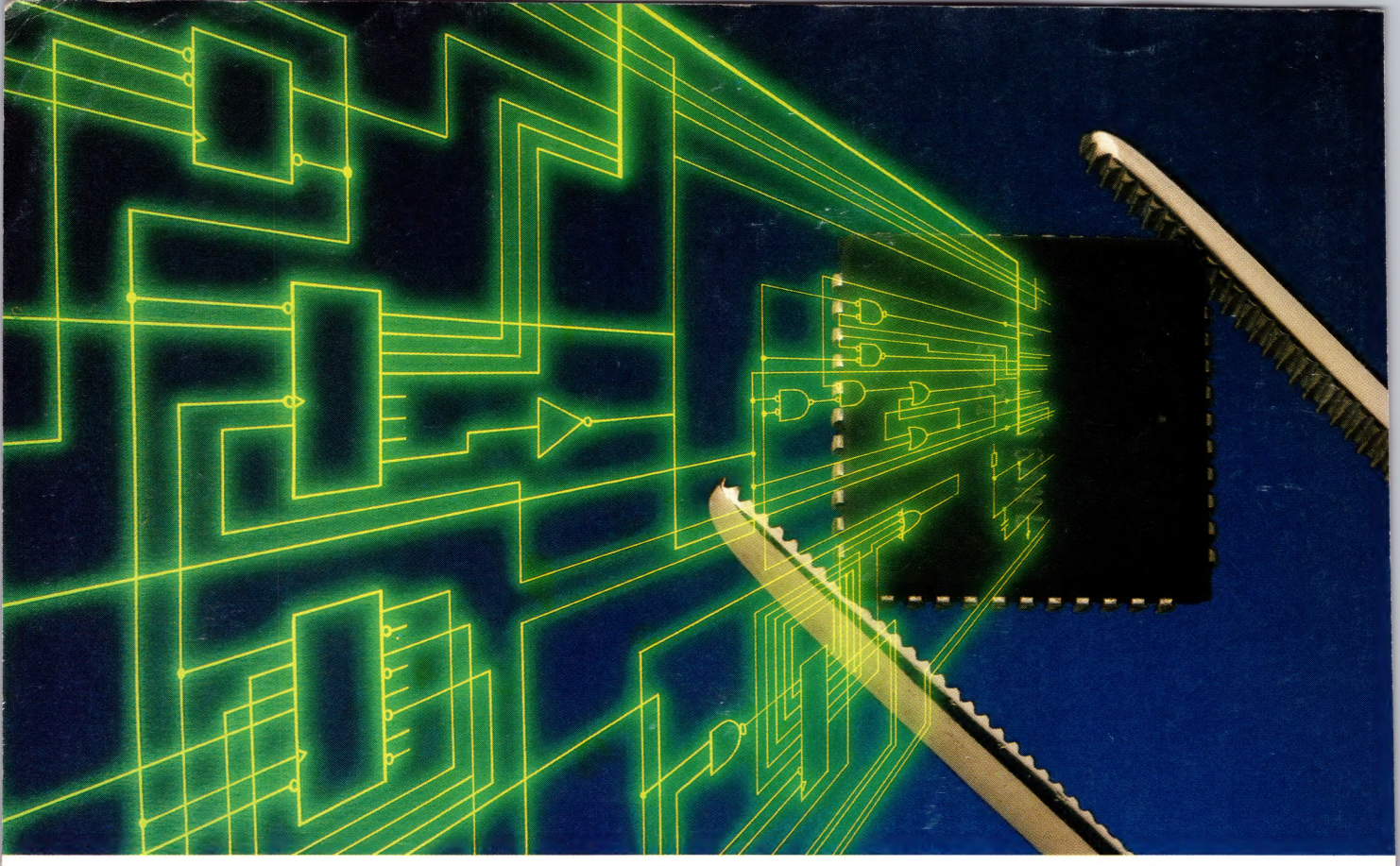

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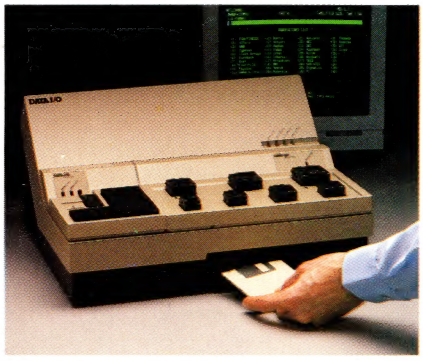

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